
जड़ित स्वचालित उच्च एवं मध्यम गति की
जल फुहार प्रणालियों के डिजाइन और
संस्थापन — रीति संहिता

(पहला पुनरीक्षण)

**Design and Installation of Fixed
Automatic High and Medium
Velocity Water Spray System —
Code of Practice**

(First Revision)

ICS 13.220.10

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Fire Fighting Sectional Committee had been approved by the Civil Engineering Division Council.

The term 'Water Spray' refers to the use of water in a form having a pre-determined pattern, particle size, velocity and density discharged from specifically designed nozzles or devices.

Water spray systems are usually applied to special fire protection problems since the protection can be specifically designed to provide for effective fire control, extinguishment, prevention or exposure fire protection. These systems may be independent of or supplementary to other forms of protection. Water spray systems are most commonly used to protect processing blocks, processing equipment, structures, flammable liquids and gas vessels, piping and equipment, such as transformers, oil switches and some combustible solids, cable trays, cable racks, etc.

In situations where oil and flammable liquids are stored and/or used in such quantities and in such manner that the value of the standard sprinklers in the event of fire is open to question, medium and/or high velocity sprayers may be employed in lieu of or in conjunction with sprinklers. This standard is intended to provide a guide as to when such systems should be installed, details of their design and performance.

This standard was first published in 2003 with a view to providing minimum requirements for fixed water spray systems based upon sound engineering practices and with assistance from the then Tariff Advisory Committee. The earlier version of this standard covered the provision of water supplies, components to be used, installation and testing of the system, maintenance, and the extension of existing systems.

This revision has been taken up to include various new technologies that have been developed in the last few years and to make it at par with the international practices. All the principles of 2003 version have been retained in this version as well, while amplifying the details with due regard to latest technological innovations and improvements in the last decade in process technology, storage in case of plants and also in firefighting methodologies.

The major changes in this revision include the following:

- a) Provisions on drawings and documentation depicting layout of water spray system including water supply have been detailed.
- b) Initial considerations for arriving at the number, system and type of water spray technique have been included in detail.
- c) New provisions on selection and types of spray nozzle have been included.
- d) New provisions on components of spray system installation have been included.
- e) Water supply requirements for spray systems and necessary pumping arrangements have also been included in detail.

Nothing in this standard prevents introduction of new concepts and technologies, when such systems are at least equivalent to various provisions of this standard and backed up by successful full scale fire testing in recognized test laboratories where the design criteria and test results have been fully documented.

The composition of the Committee responsible for the formulation of the standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of specified value in this standard.

Indian Standard

DESIGN AND INSTALLATION OF FIXED AUTOMATIC HIGH AND MEDIUM VELOCITY WATER SPRAY SYSTEM — CODE OF PRACTICE

(*First Revision*)

1 SCOPE

1.1 This standard specifies minimum requirements for design, installation and maintenance of fixed automatic water spray systems in general areas of plants/industrial buildings (high hazards, in general), various types of storage tanks (containing flammable liquids) in the open tankage areas, cable cellars in power stations and large power houses, material carrying conveyors, etc.

1.2 This standard covers only the types of water spray nozzles specified in 6 (see 6.2 and 6.3 in particular for details).

1.3 The requirements of this standard are also applicable to any addition, extension, repair or other modification to an existing water spray system.

1.4 The requirements of this standard are also applicable to the water spray systems also known as deluge systems. It is not the intention of this standard to cover other types of systems like automatic sprinkler system, foam sprinkler system, vapour mitigation system, etc.

1.5 The requirements are not valid for certain specific applications like those on ships, in aircrafts, on vehicles and for below ground systems in the mining industry and the like.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Automatic Detection Equipment — Equipment which will automatically detect one or more components directly related to combustion, such as heat, smoke, flame and other phenomenon, and cause automatic actuation of alarm and protection equipment.

3.2 Automatic Spray System — A special fixed pipe system connected to a reliable source of fire protection water supply and equipped with water spray nozzles for specific water discharge and distribution over the surface or area to be protected. The piping system is connected to the water supply through an automatically actuated deluge valve, which initiates flow of water.

NOTE — Automatic actuation is achieved by operation of automatic detecting equipment installed along with water spray nozzles. High velocity and medium velocity systems are the types. Spray systems designed to actuate when a sensor detects a fire; and no interface operation or action by personnel is required.

3.3 Class A Liquid — Liquids having flash point below 23°C.

3.4 Class B Liquid — Liquids having flash point of 23°C and above but below 65°C.

3.5 Class C Liquid — Liquids having flash point of 65°C and above but below 93°C.

3.6 Combined System — A system of piping that connects both hydrant or sprinkler system with the water spray system (also called tapped system) and is supplied by a common piping and actuation valve.

3.7 Control of Burning — Application of water spray to the source of the fire or fuel surface to reduce the rate of burning and heat release from a fire until the source of fuel can be shut off, the fire can be extinguished or the fuel is all consumed.

3.8 Deluge Valve — A quick opening system actuation valve which allows water to flow into a piping system to discharge from all open pipes or spray nozzles. A deluge valve can be opened automatically, in response to a detection system installed in the area being protected or by manual operation in an area remote from the fire area.

3.9 Density — The unit rate of water application to an area or surface expressed in litres/min/m² (lpm/m²).

3.10 Distribution Pipes — A pipe feeding either a range pipe directly or a single sprinkler on a non-terminal range pipe more than 300 mm long.

3.11 Electrical Clearance — The air distance between the water spray equipment, including piping and nozzles, and un-enclosed or un-insulated live electrical components at other than ground potential.

3.12 Envelope — The three-dimensional space enclosing the fire.

3.13 Exposed Equipment — Equipment subject to fire damage, usually from a source other than the equipment being protected.

3.14 Exposure Protection — The absorption of heat through application of water spray to structures or equipment exposed to a fire or radiant heat from a fire, or heat buildup due to sunrays in extreme hot weather to limit surface temperature to a level that will minimize damage and prevent failure.

3.15 Extinguishment — Occurs when combustion is no longer present.

3.16 Fire Barrier — A fire barrier is a continuous wall or floor that is designed and constructed to limit the spread of fire.

3.17 Fire Proofing — The application of a fire resistant material to minimize the effects of fire exposure by flame impingement, to reduce the rate of temperature rise of the material and to delay heat-induced structural failure.

3.18 Flash Point — The minimum temperature at which the liquid gives so much vapour that this vapour, when mixed with air, forms an ignitable mixture and gives a momentary flash on application of a small pilot flame under specified conditions of test.

3.19 Gauge

3.19.1 'A' Gauge — Pressure gauge connected to a town main connection between the supply pipe stop valve and the non-return valve.

3.19.2 'B' Gauge — Pressure gauge connected to and on the same level as an deluge valve, indicating the pressure on the upstream side of the valve.

3.19.3 'C' Gauge — Pressure gauge connected to and on the same level as an deluge valve, indicating the pressure on the downstream side of the valve.

3.20 Impingement — The striking of a protected surface by water droplets issuing directly from projectors and/or sprayers.

3.21 Insulated Equipment — Equipment, structures and vessels provided with insulation which for the expected duration of exposure, will protect steel from exceeding a temperature of 454°C (850°F) for structural members and 343°C (650°F) for vessels.

3.22 Manual Spray Systems — Spray systems that must be actuated by a person.

3.23 Non-absorbing Ground — Earth or fill that is not readily permeable or absorbent to large quantities of flammable or combustible liquid or water or both.

3.24 Pilot Sprinkler — An automatic sprinkler or thermostatic fixed temperature release device used as a detector to pneumatically or hydraulically release the system actuation valve.

3.25 Range Pipes — Pipes on which sprinklers are attached either directly or through short arm pipes, which do not exceed 300 mm in length.

3.26 Run Down Coverage — A protective water film flowing down by gravity onto lower portions of equipment (such as vessels or towers) from water applied to higher portions

3.27 Slippage — The horizontal component of the travel of water along the surface beyond the point of contact caused by the momentum of water.

3.28 Spray Nozzle — A normally open water discharging device which, when supplied with water under pressure, will distribute the water in a special directional pattern peculiar to the particular device.

NOTE — Nozzles used for high velocity water spray systems are called 'projectors' and nozzles used for medium velocity water spray systems are called 'sprayers'. Both these nozzles are made in a range of orifice sizes with varying discharge angles so that designed water density can be achieved for optimum protection.

3.29 Water Wastage — The discharge from water spray nozzles that does not impinge on the surface being protected.

4 DOCUMENTATION

4.1 Preparation of Drawings

Drawings shall be prepared in accordance to the following:

- a) Drawings shall be clear, contain all required details including scale and point of compass and shall be dated.
- b) Drawings of new installation shall show the entire compound; all buildings therein, with their door and window openings, and the boundary walls. Buildings under construction and future extension envisaged shall be indicated by dotted lines.
- c) Drawings of extensions to approved existing installations need not show the rest of the compound but sufficient details shall be given of the existing installations, in correlation to the extension, to enable the authorities concerned to check the plans and offer comments.

- d) In case of storeyed buildings, drawings submitted shall include plans of each storey together with sectional elevations.
- e) Drawings shall be on white paper or ammonia paper or ferro prussiate paper.
- f) Drawings shall generally be prepared in accordance with SP 46, shall not exceed 850 mm × 1200 mm in size and shall be drawn to a scale of 1 : 500 or 1 : 1 000. In the case of very large compounds with more than one building, it is advisable to submit separate drawing for each risk with a key plan showing the relative situation of the various buildings, etc, in the compound.

4.2 Drawings Illustration

Drawings illustration shall also depict the following details:

- a) *Pucca* walls to be shown by double lines, doors and windows being clearly marked.
- b) Iron or other non-masonry walls to be shown by a thin line and nature of construction indicated.
- c) Fire walls to be indicated by the sign 'fire wall' at each end of the wall alongside or across them at regular intervals and marked in distinctive colours.
- d) Fireproof doors and/or shutters to be marked as follows:
 - 1) Single fireproof door and/or shutter : 'SFD'; and
 - 2) Double fireproof door and/or shutter : 'DFD'
- e) Skylights to be marked 'sky lights' or 'SL'.
- f) Boiler to be shown by a rectangular figure marked 'boiler'.
- g) Sprayer mains to be shown by a green line, the diameter, length and number of pipes being marked alongside and specials and reducers to be clearly indicated, such as 'mm dia', lengths of 'm each'.
- h) Sprayer pumps to be clearly marked, and the capacity and head to be indicated in each case.
- j) Pump(s) suction piping to be shown dotted and diameter to be indicated.
- k) Fire service water tanks and reservoirs to be shown to scale.
- m) Sprayer trunk mains to be shown by a green line, the sizes being marked alongside.
- n) Fire alarm bells to be shown by a green line, the sizes being marked 'F.A.B.'
- p) Sprayed blocks to be marked 'SP'.
- q) Electric cable(s) for the fire pump(s) to be shown in green line(s).
- r) Material specifications of equipment and components of the installation, indicating the name of manufacturers and Indian Standards specifications, if any.
- s) In the case of internal appliances, details of the areas of the various compartments, their occupation, and the quantities and types of appliances proposed.
- t) In the case of sprayer and hydrant installations, fully dimensioned plans in duplicate shall be submitted.

4.3 In addition to the above, the following details would be necessary in the case of sprayer installation:

- a) Drawings showing layout of the entire sprayer system incorporating material specifications, different sizes of mains, etc.
- b) Each sprayer layout drawing shall indicate the details of sprayers used like, number of sprayers, type, K-factor, etc.
- c) Number of sprayers on each deluge valve set.
- d) Height of highest sprayer on each deluge valve set.
- e) Type(s) of installation(s) and the nominal diameter(s) of the main deluge valve.
- f) Number or reference of each deluge valve set.
- g) Layout of pump house showing clearly the suction, delivery and priming (if any) and freeboard arrangements.
- h) Details of water storage tanks giving particulars of compartmentation and common sump, details of inflow and levels for tappings for suction, inflow, overflow and free board levels.
- j) Sub-station location in relation to other blocks if the pump is electrically driven.
- k) Route of cable from substation to fire pump house.
- m) Schematic circuit line diagram showing electric feed to fire pump.
- n) A statement that the system will comply with this specification including details of any deviations from its recommendations with the reasons for the deviations.
- p) A list of the components suitable for sprayer use included in the system, each identified by manufacturer's name and model/reference number.

4.4 Installation Layout Drawings

4.4.1 General

The scale shall be not less than 1 : 100. Layout drawing shall include the following information:

- a) North point indication.
- b) Class or classes of installation according to hazard class including stock category and design storage height.

- c) Constructional details of floors, ceiling, roofs and exterior walls, and walls separating sprinkler/sprayer protected and non-sprinkler/sprayer protected areas.
- d) Sectional elevations of each floor of each building showing the distance of sprayers from ceiling, structural features, etc, which affect the sprayer layout or the water distribution from the sprayers.
- e) Location and size of concealed roof or ceiling voids, offices and other enclosures sealed at a level lower than the roof of ceiling proper.
- f) Indication of trunking, staging, platforms, machinery, fluorescent light fittings, heaters, suspended open cell ceilings, etc, which may adversely affect the sprinkler/sprayer distribution.
- g) Sprinkler types(s) and temperature ratings(s), sprayer types.
- h) Location and type of main control/deluge valves and location of alarm motors and gongs.
- j) Location and details of any water flow and air or water pressure alarm switches.
- k) Location and size of any tail-end air valves, subsidiary stop valves and drain valves.
- m) Drainage slope of the pipe work.
- n) Location and specification of any orifice plate.
- p) A schedule listing the numbers of sprinklers, medium and high velocity sprayers, etc, and the area of protection.
- q) A key to the symbols used.

4.4.2 Hydraulically Calculated Pipe Work

For hydraulically calculated pipe work, the following shall be given with detailed calculations, either as purpose designed work sheets or as a computer print-out:

- a) For each design area of operation:
 - 1) Area identification.
 - 2) Hazard class.
 - 3) Specified density of discharge (lpm/m²).
 - 4) Area covered per sprayer (in m²).
 - 5) Detailed and dimensioned working drawings showing the following:
 - i) Node or pipe reference scheme used to identify pipes, junctions, sprayer heads and fittings which need hydraulic consideration; and
 - ii) Height above datum of each point of identified deluge valve.
- b) For each operating sprayer:
 - 1) Sprayer node or reference number;
 - 2) Sprayer nominal K-factor and discharge angle;
 - 3) Flow through the sprinkler (in l/min); and
 - 4) Inlet pressure to the sprinkler or sprayer assembly (in bar).
- c) For each hydraulically significant pipe:
 - 1) Pipe node or other reference;
 - 2) Pipe nominal bore (in mm);
 - 3) Hazen-Williams constant (C or K-factor) for the pipe;
 - 4) Flow through pipe (in l/min);
 - 5) Nominal fluid velocity (in m/s);
 - 6) Length of pipe (in m);
 - 7) Numbers, types and equivalent lengths of fittings;
 - 8) Static head change in pipe (in m);
 - 9) Pressures at inlet and outlet of pipe, in bar;
 - 10) Friction loss in pipe (in bar); and
 - 11) Indication of flow direction.

NOTE — A line diagram of the pipe layout should be prepared showing the following:

- a) node or pipe reference numbers;
- b) distribution pipes,
- c) range pipes, and
- d) sprayer heads under consideration.

4.5 Water Supply Drawings

The drawings shall show water supplies and pipe work therefrom upto the installation control valves. The drawings shall be on an indicated scale of not less than 1 : 100. A key to the symbols shall be included. The position and type of stop and check valves and any pressure reducing valve, water meter, water lock, orifice plate and any connection supplying water for other services shall be indicated.

5 INITIAL CONSIDERATIONS

5.1 Consultation

Where a spray system or an extension or alteration to a spray system is being considered for new or existing facilities, the authorities concerned shall be consulted at an early stage.

5.2 Outline Design

Consideration should be given to any benefits that might be gained by changes in building design, work procedures, etc, when preparing the outline design. In planning site layout and building/tankage design, particular consideration should be given to the following:

- a) Occupancy which determines the water discharge density and water supply pressure, and flow;
- b) Siting of any main water supply connection(s);
- c) Siting of any water supply tank(s) or reservoir;
- d) Siting of any pump house;

- e) The maximum quantity of water available from the supply source compared with the system requirements
- f) Location of deluge valves together with the access thereto; indication of position of valves; and the disposal of drainage and water after any test;
- g) Source and means of supply of electric power, etc; and
- h) Protection of deluge valves(s), pipe work within and outside the plant/tankage facilities against accidental damage.

5.3 It is important to consider building design in the context of fire protection, for example, choice of materials, support of spray pipe work having regard to the load imposed on building structure/tankage by the weight of spray pipe work and the contained water, need for inbuilt drainage, etc.

5.4 Design Objectives

The following objectives shall be considered in the design:

- a) Protection with water spray systems shall be considered as best option in case of following:
 - 1) Fire extinguishment,
 - 2) Control of burning,
 - 3) Exposure protection, and
 - 4) Fire prevention.
- b) A study shall be made of the physical and chemical properties of the materials for which the water spray protection is being considered to determine the advisability of its use.
- c) The flash point, specific gravity, viscosity, miscibility, and solubility and permeability of the material, temperature of the water spray, and the normal temperature of the hazard to be protected are among the factors that shall be given consideration.
- d) Where water spray can encounter confined materials at a high temperature or with a wide distillation range, the slop-over or frothing hazard shall be evaluated.

5.5 Supplementary Information

The following supplementary information may also be considered, as applicable:

- a) Where protecting water soluble materials such as alcohol, systems shall be permitted to be designed for extinguishment by control, extinguishment by dilution or extinguishment by an adequate application rate and coverage.
- b) Each water soluble material shall be tested under the conditions of use to determine the applicability of a water spray system, unless design supportive data is available.

- c) Water spray shall not be used for direct application to materials that react with water, such as metallic sodium or calcium carbide, which produce violent reactions or increase hazardous products as a result of heated vapour emission.
- d) Water spray shall not be used for applications involving liquefied gases at cryogenic temperatures (such as liquefied natural gas), which boil violently when heated by water.
- e) An evaluation shall be conducted, given the possibility of damage, distortion or failure of equipment operating at high temperatures due to water spray application.

5.6 Interaction with Other Fire Protection Measures

Account shall be taken of possible interaction between spray systems and other fire protection measures. Examples of possible adverse interactions between spray protection and other fire protection measures, which need specific considerations, are:

- a) Water damage to an inadequately shielded fire alarm control panel in a spray protected area with consequent possible failure of the fire alarm system.
- b) Operation or failure of smoke detectors in zones adjacent to one in which water discharge has taken place because of the water spray mist travelling to adjacent zones.
- c) It is possible that water spray protection for plant/equipment is independent through dedicated pumping facilities or tapped from hydrant protection already available in the premises. While the design of the system in either case shall remain same with regard to provision of sprayers, piping, etc pumping capacity and water storage requirements for the hydrant system shall be suitably increased to take care of additional load.
- d) Determining the need for water spray protection at various locations, particularly in petrochemical plants, refineries, bottling plants, etc, includes an evaluation of the extent and capabilities of other types of fire protection both active and passive ones. Various options are available to protect equipment and shall be explored to determine the most suitable approach for a specific hazard or area. Major factors to be evaluated include but are not limited to the following:
 - 1) Fire separation spacing between various plant units, equipment, etc.
 - 2) Fireproofing of building structures and also flammable storage tanks inside and outside plant battery.
 - 3) Vertical height of columns and equipment where other fire protection measures are not possible.

- 4) Safe shutdown systems, both manual and automatic shutdown.
 - 5) Access to the cluster of equipment due to radiant heat, obscured visibility, lack of access to hose streams, etc.
 - 6) Safe blow down of flammable liquids and vapour phase contents of the plants to blow down drums, pits or sumps and/or flare or any other safe location.
 - 7) Response times and capabilities of plant and other fire brigades.
 - 8) Fire hydrant system with pumps, fixed monitors, portable monitors and hose streams, and foam systems.
 - 9) Prolonged water application facilities to facilitate safe shutdown and removal of flammables.
 - 10) The availability of portable and mobile firefighting equipment and personnel to operate it.
 - 11) Drainage facilities for flammable liquids/hydrocarbon from a spill area.
 - 12) Hold-up of flammable liquids/hydrocarbon inside plants, temperature, and volatility.
 - 13) Protection with passive as well as active systems for most critical equipment.
 - 14) Public liability to the adjoining surroundings arising out of leakage of flammable and toxic chemicals
- e) Such possible interactions need careful considerations.

6 SPRAY NOZZLES

6.1 General

Water spray systems are usually applied to special fire protection problems beyond the capability of a standard sprinkler system. They are specifically designed for fire control, extinguishment, prevention or exposure protection. These systems typically require that water be applied rapidly and uniformly to all protected surfaces at the same time, an objective that may not be possible with closed nozzles.

In addition, to protect specific surfaces, the use of special nozzles with directional discharge is employed. The placement of these nozzles to provide proper coverage is often in conflict with the required placement to ensure prompt operation where automatic nozzles are used. Thus, the standard suggests that open nozzles will normally be employed and that a separate detection system will be used to actuate the system.

There are cases, however, where it is desirable to use closed nozzles to limit the discharge of water to prevent equipment damage (such as when water spray is used

for local protection of sensitive equipment like turbine bearings) or there are environmental concerns.

Automatic nozzles shall only be used where open nozzles present such problems and the position of the nozzles can meet both the coverage and response time as required under design objectives.

6.2 Selection of Nozzles

Nozzles shall be always of open type. Automatic (closed) nozzles shall be permitted where positioned and located so as to provide satisfactory performance with respect to activation time and distribution. The selection of the type and size of spray nozzles shall be made with proper consideration given to such factors as discharge characteristics, physical character of the hazard involved, ambient conditions, material likely to be burning, and the design objectives of the system.

Where acceptable to the Authority having jurisdiction, sprinklers shall be permitted to be used in water spray systems and installed in positions other than anticipated by their listing to achieve specific results where special situations require. Water spray nozzles can be permitted to be placed in any position, within their listing limitations, necessary to obtain proper coverage of the protected area. The positioning of water spray nozzles shall include an evaluation of all the following factors:

- a) Shape and size of the area to be protected;
- b) Nozzle design (end connection and material of construction) and characteristics of the water spray pattern to be produced;
- c) Effect of wind and fire draft on very small drop sizes or on large drop sizes with little initial velocity;
- d) Potential to miss the target surface and increase water wastage;
- e) Effects of nozzle orientation on coverage characteristics; and
- f) Potential for mechanical damage.

6.2.1 Nozzles shall be of the type that has been tested and listed for use in water spray systems. The selection of specific spray involves consideration of the following factors:

- a) Characteristics of the equipment to be protected;
- b) Purpose of the system;
- c) Discharge characteristics of the nozzle;
- d) Possible wind or thermal draft conditions;
- e) Equipment configuration and spacing requirements;
- f) Corrosive water or atmospheric conditions;
- g) Water flow rate requirements *versus* availability; and
- h) Drainage.

The effective range of the spray is determined by the velocity and the size of the water droplets. Because of differences in orifice size, nozzle characteristics, and discharge patterns, one type of nozzle cannot ordinarily be substituted for another without proper analysis.

6.3 Type of Nozzles

Three types of nozzles namely, high velocity, medium velocity and drencher type (window and curtain) are covered as per this standard, and each of them has their own application in protection with water spray systems. Design requirements for the same are covered in detail in 7 and 8. Nozzles used for high velocity water spray systems are called 'projectors' and nozzles used for medium velocity water spray systems are called 'sprayers'. Both these nozzles are made in a range of orifice sizes with varying discharge angles so that discharge can be controlled for optimum protection.

6.3.1 Medium Velocity Water Spray System

Nozzles are generally used for spray angles between 60° and 140°. They are recommended for usage in various applications with different K-factors between 18 and 100. These nozzles are used in the protection of high hazard plant areas, horizontal tanks like bullets, spheres, vertical atmospheric fixed and floating roof type tanks, conveyors, cable cellars and similar applications.

6.3.2 High Velocity Water Spray System

Nozzles are generally used for spray angles between 65° and 150°. They are recommended for usage in applications with different K-factors between 18 and 110. These nozzles are generally used for oil filled equipment like transformers and other types of oil tanks.

6.3.3 Drencher Type (Window and Curtain) Nozzles

Water curtain nozzle distributes water in a flat curtain extending all the way to the ground. Water curtain nozzle, when mounted in pendent position, acts as a window, spray nozzle to protect interior walls, windows and other opening of the building which are affected by fire. The nozzles, when mounted in horizontal position with flow towards ground, a flat water curtain are produced to segregate the area which is under fire. They are generally used in applications with different K-factors, between 20 and 140.

There are restrictions in choosing K-factor and sprayer angle for various types of protection and the same are incorporated under each application.

7 HIGH VELOCITY WATER SPRAY SYSTEMS

7.1 General

High velocity water spray systems are installed to extinguish fires involving liquids with flash points

of 65°C (150°F) or higher. Three principles of extinguishment are employed in the system, namely, emulsification, cooling and smothering. The result of applying these principles is to extinguish the fire within a few seconds. Guidelines for protection of the following are covered hereunder:

- a) Transformers, oil filled equipment of power stations;
- b) Turbo-alternators; and
- c) Oil-fired boiler rooms and oil quenching tanks.

7.2 Transformer Protection

7.2.1 General

7.2.1.1 Transformer protection shall contemplate on essentially complete impingement on all exterior surfaces except the underside, which may be protected by horizontal projectors.

7.2.1.2 Transformers present particular design problems for water spray protection, primarily due to their irregular shape and necessary clearances to be provided for the high voltage equipment. Generally speaking, there is much more interference with the water flow on the sides of the transformer than at their top. Due to this reason, the protection usually involves a large number of small capacity projectors than a few bigger ones. Often it will be necessary to put more water on the transformer than required to achieve complete impingement and total envelopment.

Hence, it is necessary to submit the following information with detailed drawings to check the design of spray system of a transformer:

- a) Length of the transformer;
- b) Width of the transformer;
- c) Height of the transformer;
- d) Location and height of bushings;
- e) Size and location of oil conservator tank;
- f) Location of switch boxes, tap changing gears and other equipment that obstruct and interfere with water distribution;
- g) Specification, such as kVA rating, voltage rating, oil quantity, etc;
- h) Details showing the direction of incoming and outgoing cabling and ducting;
- j) Details of flooring on which the transformer is installed and nature of floor around the transformer such as concrete, asphalt, pebble filled, etc;
- k) Elevation of transformer above the grade;
- m) Size and location of fire barrier walls;
- n) Siting of radiators and cooler banks in relation to the transformer and the surrounding ground level;
- p) Protection and detection piping in different colours; and

- q) Projector characteristics showing the 'K' factor, cone angle, discharge in litres per minute and effective reach.

7.2.1.3 The drawings shall clearly show top, sides and bottom of the transformer and also isometric views showing all the above details. Also the piping, explosion vents, flanges, etc should be clearly shown.

7.2.1.4 The projection from the surfaces like ribbings, tap changers, cable boxes, etc, would 'roof off' the downward flow of water and hence 'run down' cannot be automatically considered. Such 'roofed off' areas will require specific spray coverage with additional projectors.

7.2.2 Electrical Clearance

All system components shall be so located as to maintain minimum clearances from live parts as shown in Table 1. 'Clearance' is the air distance between water spray equipment including piping nozzles and detectors and, uninsulated live electrical components at other than ground potential. The minimum clearances specified in Table 1 are under normal conditions. During the operation of water spray system, they are intended for use as safe. The values stated are as per requirements of SP 30.

Table 1 Minimum Clearances
(Clause 7.2.2)

Sl No.	Maximum RMS Value of Rated Operation Voltage kV	Minimum Distance of Installation Subject to Over-voltages mm	Minimum Distance of Installations Protected Against Over-voltages or Connected to Cables mm
(1)	(2)	(3)	(4)
i)	10	150	150
ii)	20	215	160
iii)	30	325	270
iv)	45	520	380
v)	60	700	520
vi)	110	1 100	950
vii)	150	1 550	1 350
viii)	220	2 200	1 850
ix)	400	3 500	3 000

7.2.3 Strainers (see also 9.14)

Pipeline strainers shall be of approved type for use in water supply connections. Strainers must be capable of removing from the water all solids of sufficient size to prevent the spray nozzles from clogging (normally 3.2 mm perforations are suitable). In addition, the strainer must be capable of continuous operation

without serious increase in head loss, for a period estimated to be ample when considering the type of protection provided, the condition of the water and similar local circumstances. Also, pipeline strainers must incorporate a flush out connection. Individual strainers for spray nozzles where required must be capable of removing from the water all solids of sufficient size to obstruct the spray nozzle they serve.

7.2.4 General Layout and Design

7.2.4.1 Transformers shall be protected using rings of nozzles there around with the top of transformer and subsequently rings for every 3 m from top to bottom thereof and beneath each continuous obstruction. The rings shall not be located at more than 1 m of the transformer.

7.2.4.2 Projectors shall be employed to spray water horizontally at the bottom if the transformer is at more than 300 mm above ground level.

7.2.4.3 In case of transformers surrounded by concrete or asphalted surfaces, projectors must be employed in such a way as to wash off flammable liquids away from transformers.

7.2.4.4 Piping network shall be planned with more flanged connections in such a way that removal of transformer is smoothly enabled by removal of very few connections. This also will be helpful in restoring the protection to the transformer (after servicing) without delay or downtime.

7.2.4.5 Projectors

- Projectors shall not be less than 6 mm orifice, in size;
- Projectors protecting the top shall be aimed at an angle so that all of the water impinges upon the transformer, the spray pattern targeting either the top of the transformer or partly the top and partly the sides;
- Projectors protecting the vertical sides and the bottom of the transformer shall point directly on the surfaces to be protected;
- Projectors protecting irregular areas shall be located for the best coverage;
- Projectors protecting the space between transformers and radiators and/or space between radiators shall be so located as to spray directly into the open space;
- Where the components of the transformer create spaces greater than 400 mm, such surfaces shall be individually protected as far as possible;
- As far as possible, water spray piping shall not be routed across the top of the transformer tank or across the face of the transformer cabinet. When it is difficult to achieve this, piping shall be routed

across the top and face of the cabinet subject to maintain requisite distance from the live electrical components;

- h) Projectors shall cover the conservators, oil pipe joints and flanges, and pumps, if any; and
- j) Direct impingement of water spray on energized bushings and/or lightning arresters shall be permitted only when authorized by the manufacturer or by the electrical inspectorate.

7.2.4.6 Fire barrier walls (Baffle walls)

Fire barrier walls shall be constructed between the transformers/equipment when the aggregate oil capacity of the transformer or bank of transformers exceed 2 000 l and these walls shall be of either 355 mm thick brick or 200 mm thick RCC and carried at least 600 mm above the highest point of equipment to be protected.

Fire barrier wall shall be constructed between the transformers/equipment, which are not spaced at distances mentioned in Table 2.

Table 2 Separating Distances
(Clause 7.2.4.6)

Sl No.	Oil Capacity of Individual Clear Separating Transformers litre	Distance m
(1)	(2)	(3)
i)	Upto 5 000	6.0
ii)	Between 5 001 and 10 000	8.0
iii)	Between 10 001 and 20 000	10.0
iv)	Between 20 001 and 30 000	12.5
v)	Over 30 000	15.0

7.2.4.7 System design

For control mode, water shall be applied at a rate of not less than 10.2 lpm/m² of the surface area of the entire transformer including the bottom surface, radiators, conservators, etc. For suppression mode, the density applicable shall not be less than 15 lpm/m². Density may be reduced to 6.1 lpm/m² for spills on the expected non-absorbing ground surface area of exposure. The following shall also be taken care of:

- a) Projectors on the rings shall be located at not less than 500 mm and not more than 800 mm from the transformer/equipment surface.
- b) The horizontal distance between the projectors shall be maintained in such a way that their spray patterns intersect on the surface of transformer/equipment which, in any case, shall not be more than 1.5 m.
- c) Obstructed or 'roofed off' portions (*see 7.2.1.4*) of the transformers shall be protected by separate

projectors. For this purpose, it will be permissible to extend pipes from the nearest ring by means of a nipple. The terminal pipes extended from the ring mains shall need separate supports if they are 600 mm or longer.

- d) Where radiators or cooler banks are located at more than 300 mm from the surrounding ground level, undersides shall be protected by projectors pointing upwards.
- e) Where radiator/cooler bank are spaced more than 300 mm apart and where the transformer is separated at a distance of more than 300 mm from the radiator/cooler bank, projectors shall be so arranged to spray into the space. Projector angles shall be so selected that the cone diameters at the entrance of space is equal to or slightly larger than the space.
- f) For unobstructed vertical surface, the maximum vertical distance between projectors shall be 2.5 m. However, for obstructed surface the distance shall be governed by the nature of obstruction.
- g) Nozzles shall be positioned such that the water spray does not envelop energized bushings or lightning arresters by direct impingement.
- h) The system shall be hydraulically so designed that the pressure at the hydraulically most remote projectors in the network is not less than 3.5 bar in case of an outdoor transformer and 2.8 bar in case of an indoor transformer. However, the maximum pressure in any projector within a network shall not exceed 5 bar. The velocity in the feed pipes shall not exceed 10 m/s.

7.2.5 Detection System for Transformers

Automatic detection equipment shall be so located and adjusted as to operate reliably. The location of detectors shall be based on several factors, such as nature of hazard, air velocity, temperature variations, and configuration of the hazard, indoor or outdoor, open or closed structures and other variables. For transformers the detector sprinklers shall be as close to the shell as possible at all places subject to electrical clearance.

7.2.5.1 Outdoor transformers

There shall be a ring of detectors around the top of the transformer and a second ring around the base. The detectors shall be spaced at a maximum of 2.5 m intervals. The detectors shall be as close to the transformer as possible and shall in no case be farther than 300 mm therefrom. Additional detectors shall be required for specific known hazard points, such as tap changers, cable boxes, vents, oil piping, etc. Coolers and radiator banks associated with the transformer shall also be provided with detectors at two levels. The flanges of oil pipes shall be within 300 mm from detectors. The conservator tanks shall be provided with detectors at 2.5 m spacing. It is

sufficient to install detectors under the conservator tanks.

Piping shall be individually supported as far as possible. Transformer ribbings may be used to support the piping. In no case, shall the piping be supported on body of transformer. Terminal pipes (other than those for projectors protecting 'roofed off' portions) longer than 300 mm shall be supported separately. Piping shall be individually supported as far as possible. Transformer ribbings may be used to support the piping. In no case shall the piping be supported on the body of the transformer.

NOTE — Pipe work is likely to be affected by stray magnetic fields that can produce inductive heating if there is a continuous metallic ring. Hence, continuous ring mains shall be avoided.

7.2.5.2 Indoor transformers

Where the transformer cubicle is open fronted, the same shall be treated as an outdoor transformer with detectors as per 7.2.5.1. Where the transformer cubicle is more than 6 m in height, the detectors shall be positioned as close to the transformer as possible to the top of the transformer. Where the transformer cubicle is less than 6 m in height, the detectors shall be positioned in accordance with IS 15105, that is, at a maximum spacing of 4 m with an area coverage of not more than 12 m².

7.3 Miscellaneous Protection

7.3.1 High velocity water spray systems are also provided for the protection of following areas in power stations:

- a) Inside turbo alternator sets;
- b) Clean and dirty oil tanks, paraffin tanks;
- c) Inside turbo alternator sets; and
- d) Hydrogen cooling and seal oil systems.

7.3.2 The protection is normally localized and hence deemed as 'spot' protections as only equipment are protected and not the whole area where the equipment is installed. The details of design for protection of above areas shall be submitted to concerned authorities in advance showing the layout of equipment, their configuration, location of projectors and detectors, etc, along with detailed drawings for prior approval.

8 MEDIUM VELOCITY WATER SPRAY SYSTEMS

8.1 General

8.1.1 Medium velocity water spray systems are installed to control the burning and to provide cooling and/or exposure protection to such risks where extinguishment is always not possible or even desirable, for example, fires involving flammable fluids having flash points below 65°C (150°F). These systems are also used sometimes for power station applications in coal conveyors, cable galleries, etc.

8.1.2 Guidelines for protection of the following areas by medium velocity water spray system are covered hereunder:

- a) General area protection (working plants like LPG bottling plants, chemical/petrochemical plants where flammable solvents are stored and/or used, etc);
- b) Horizontal storage vessels (for example, LPG bullets, etc);
- c) Vertical storage vessels (for example, benzene, xylene and toluene tankage);
- d) Spherical storage vessels (for example, LPG bullets, spheres, etc);
- e) Spot protection (protection of selective areas/equipment);
- f) Material carrying conveyors for coal, coke, etc; and
- g) Cable cellars, cable galleries in large power plants and power stations.

8.2 General Area Protections

8.2.1 Definition

A process plant where flammable liquids are contained in vessels and/or pipes forming a large or small complex of the plant either in a room or outdoors or under a roof with open sides would be classified as a 'general area'. A plant wherein more than 1 000 l of flammable liquids/solvents are stored in small containers would also be classified as a 'General area'.

8.2.2 General Information

The density of water application shall depend upon the type of flammable liquids handled in the plants and also upon the object of protection and site conditions. The examples include:

- a) Controlled burning of spilt liquid;
- b) Exposure protection of plant and its structure;
- c) Ceiling height of the risk;
- d) Area of the fire involved; and
- e) Type of containers holding the flammable liquid.

8.2.3 General Requirements

8.2.3.1 Sprayers installed at ceiling level shall provide general area protection for spill fires and of un-insulated structural steel columns/trusses upto 3 m from the ceiling sprayers.

8.2.3.2 If the ceilings or roofs are of either A.C. sheet or G.I. sheet and the like or combustible materials, additional open type sprinklers shall be provided exclusively to protect them with a degree of wetting.

8.2.3.3 Where the height of ceiling/roof of the plant exceeds 13 m from the flooring below, conventional open type sprinklers shall be employed instead of sprayers.

8.2.3.4 Vessels, drums, pumps, valves, manifolds and flammable liquid pipes inside the plant shall need to be protected by sprayers installed at a lower level.

8.2.3.5 If there are obstructions extending below the ceiling sprayers and they are more than 1 m in width, underneath of such obstructions shall be protected by local sprayers.

8.2.3.6 Structural steel work supporting access platforms, catwalks, ladders, etc, may be protected by separate sprayers.

8.2.3.7 As far as possible, the sprayers installed at lower levels (*see 8.2.3.4, 8.2.3.5 and 8.2.3.6*) shall be provided with baffle plates.

8.2.3.8 Full detailed drawings of the following shall be submitted along with the proposal:

- Plan and sectional views of the risk, floor wise, showing the dimensions of the block, equipment layout, nature of floors/roof, minimum and maximum ceiling height, etc.
- Columns, beams and trusses of the supporting structure.
- Working details of sprayers, sprinklers, detectors, their piping, their spacing, zone division, etc;
- Location of deluge valves, piping, detector piping and their sizes.
- Typical mounting arrangements of sprayers, sprinklers, detectors, etc.

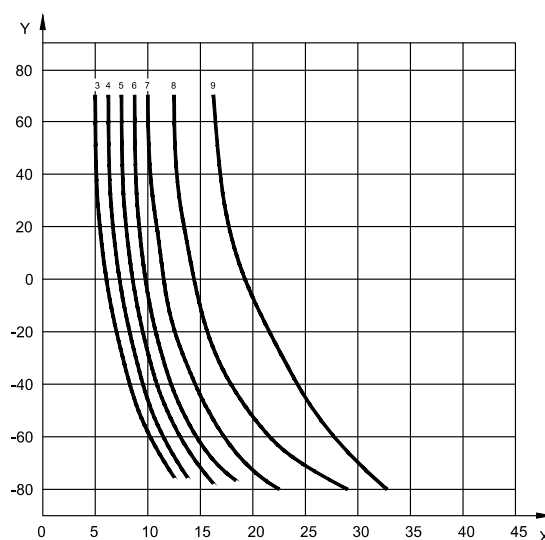
- Separate drawing showing the various nodes only for hydraulic calculation;
- Characteristic curves of sprayers and sprinklers showing their pattern, orifice size, K-factor, spray angle, discharge in lpm, etc;
- Full details of the liquids handled indicating their quantity, chemical properties etc.
- Up-to date block plan showing clearly the distances between various blocks, underground tank, mains and their size, detector mains, deluge valves, pump house, water reservoir, etc.
- A detailed note on the protection scheme elucidating the design philosophy.

8.2.4 Design Density

8.2.4.1 Design application rates are based on the intended exposure protection, control of burning or extinguishment objectives. Various clauses in this section provide more specific guidance based on the actual equipment or structure being protected. These parameters shall be discussed and agreed to by the user and authorities having jurisdiction.

8.2.4.2 The density of water application depends upon the flash point of the liquids handled and also the ceiling height of the building/structure. The correct rate of density shall be derived from Fig. 1.

8.2.4.3 The density obtained from Fig. 1 shall be loaded by the fire area factor calculated as below where 'a' is



NOTE — The ceiling height to be used in determining the density shall be the minimum distance between the floor level of the plant and the ceiling.

Control curves for the application of water on petroleum product spill fires based on flammable liquid flash point *versus* design density for various roof heights

X Axis : Density, in lpm/m²

Y Axis : Flash point of flammable liquid handled, in °C

3, 4, 5, 6, 7, 8 and 9 : Respective height of the roof, in m

FIG. 1 DESIGN DENSITY REQUIREMENTS

the longer side and 'b' is the shorter side of the fire area measured, in metres. If the risk is circular in shape 'a' may be treated equal to 'b' and same if it is square. If it is rectangular and 'a' is more than '3b', it shall be taken as equal to '3b' irrespective of the dimensions.

$$\text{Fire Area Factor} = \frac{b(a+b)}{90} + 0.33$$

NOTES

1 If the factor calculated is less than 1, the same may be taken as 1.

2 After loading the basic density with the fire area factor, if the density works out to be greater than that of close control needs, the same may be taken as that of the latter.

3 Attention is drawn to 8.2.6

8.2.5 Layout of Protection Network

8.2.5.1 The discharge cone angles of sprayers shall be selected from Fig. 2, which relates height of risk with the required angle. Any angle within shaded area is deemed acceptable.

NOTES

1 It is preferred to use wider angled sprayers at the roof according to increase in heights beyond 5 m but within 13 m.

2 Where heights of less than a metre are encountered, sprayers with discharge cone angles of 100° shall only be installed.

3 If the height of the risk exceeds 13 m, conventional sprinklers (open type) shall be installed.

8.2.5.2 The discharge cone angles of the sprayers shall be selected from Fig. 2 which relates height of the risk with the required angle. Any angle within the shaded area is deemed acceptable.

8.2.5.3 There shall be at least one sprayer for each 9 m² floor area.

8.2.5.4 The distance adjoining sprayers shall not exceed 3 m anywhere.

8.2.5.5 The distance between the last sprayer and the external wall or limits of the area shall not exceed 1.5 m anywhere.

8.2.5.6 The sprayer piping shall be installed along the slope of the roof (in case of sloping roof) but the sprayers shall discharge water on the risk in a vertical pattern.

8.2.5.7 In case of grating floors or perforated floors, the general area protection as per Fig. 1 shall be provided under the lowest floor. Under other floors, the sprayers shall be provided to discharge the floor below equipment, structural steel, etc at a rate of not less than 10.2 lpm/m².

NOTE — In case of R.C.C. floors, each floor shall be protected at the same density as determined in 8.2.4.1.

8.2.5.8 Equipment protection

If the tops of the vessels are more than 5 m below the ceiling and/or platform, individual local protection shall

be provided by sprayers at a density of not less than 10.2 lpm/m² to cover top and sides thereof. Any obstructions below the ceiling sprayers, if exceeding 1 m in width, shall be protected underneath by individual sprayers at the same density.

Similarly, under surface of vessels and equipment, if raised 300 mm above the floor level, shall be wetted by individual sprayers at the same density. Highly exposed critical pipe racks, fin fan coolers, control equipment, valves, manifolds and other protuberances shall be totally wetted by local sprayers at the 10.2 lpm/m². In case of fin fan coolers, nozzles shall be provided at the bottom of the fans also, spraying water upwards.

8.2.5.9 Pumps and compressors

Pumps that handle flammable liquids or combustible liquids at temperatures elevated above their flash points and also hot pumps handling hydrocarbons at and above 90 percent of their auto-ignition point which are located within process structures shall need to be protected when following conditions exist:

- Liquid being handled is at a temperature that is significantly above its flash point and/or is at a temperature equal to or above its auto-ignition point;
- Considered pump is in close proximity to other equipment (including adjacent pumps) or structures that could be quickly damaged by the pump fire; and
- Pump is located where protection by monitors or hose streams would be difficult or impractical.

The water spray system should be designed to envelope the entire pump including the shaft, seals and other critical parts. Optionally, the spray envelope may be extended 750 mm beyond the pump periphery, and includes suction and discharge parting flanges, check valves, gauge connections, block valves, balance lines and lubrication connections.

The application rate should be not less than 20.4 lpm/m² of the projected envelope area at grade level. Spray nozzles shall be so placed as to cover the entire envelope as stated above and the deflectors shall not be at more than 1 m from the pump and allied equipment. Protection to the compressors handling flammable gases shall follow the same philosophy as of pumps stated above.

8.2.5.10 Structural protection

In all cases, the load bearing structural steelwork for the plant and the roof, at levels exceeding 3 m below the sprayer at ceiling level, shall be wetted at a rate of not less than 10.2 lpm/m² over the surface area of the structural members.

Columns and beams shall be wetted on each side of the steel sections by staggering the sprayers. Any other structural steel work (whether load bearing or not) which can be subjected to flame impingement shall also

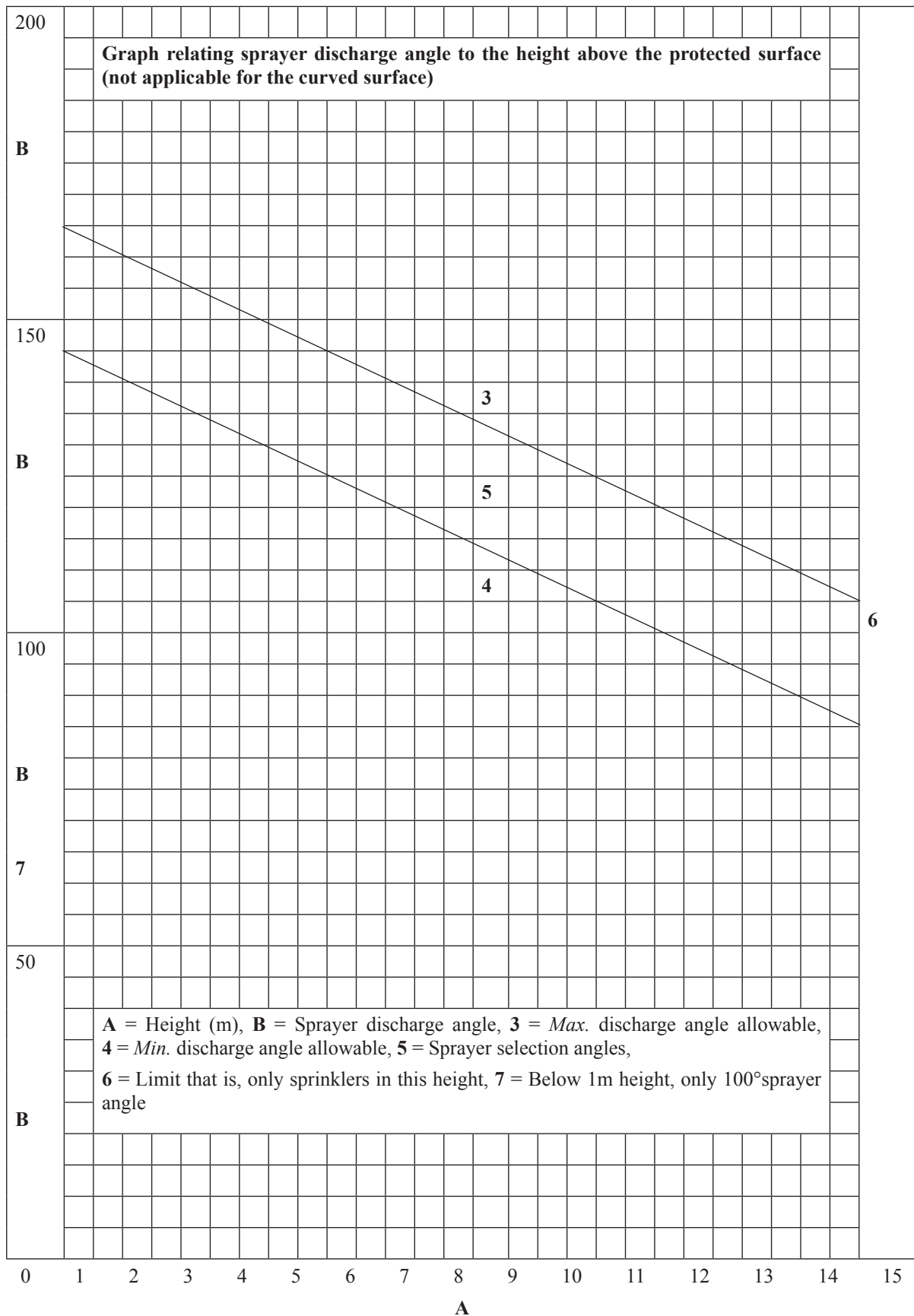


FIG. 2 LAYOUT OF PROTECTION NETWORK

be wetted at not less than 10.2 lpm/m². The density can be halved in case of structure being built entirely of R.C.C or fire-proofed structures.

NOTE — Uninterrupted 'run down' upto 3.7 m below the level of sprayers is permissible.

8.2.5.11 Roof protection

To provide wetting for the roof, conventional open type sprinklers (preferably) or sprayers shall be installed in such a way that there is at least one sprinkler/sprayer for every 9 m² area of the roof. Layout of such sprinklers/sprayers shall be in accordance with those for sprayers as stated in 8.2.5.2 and 8.2.5.3. Sprinklers/sprayers shall be installed normal to the roof and piping shall be laid along the roof (in case of sloping roof).

8.2.5.12 Miscellaneous protection

Design densities for certain other high hazard occupancies shall be as per the following:

- | | | |
|--|---|-------------------------|
| a) LPG bottling plants | : | see 8.2.4.2 and 8.2.4.3 |
| b) LPG pump house | : | 20.4 lpm/m ² |
| c) LPG cylinder storage (empty, filled, cold repair) | : | 10.2 lpm/m ² |
| d) LPG tank, truck/tank, wagon, loading/unloading gantries | : | 10.2 lpm/m ² |
| e) Hydrocarbon truck/rail loading/unloading racks | : | 10.2 lpm/m ² |

8.2.6 System Hydraulics

For the protection of large areas, it is permissible to divide the building/area into several zones of not less than 6 m and not more than 8 m in width and all zones in plan view of the risk falling within 6 m from any point within a zone shall operate simultaneously. Each zone shall be controlled by an individual deluge valve and flow through the valves shall not be more than what is specified in 9.9.3 and Table 7. Each zone shall be so designed that the pressure at the hydraulically most unfavourable sprayer/sprinkler is not less than 1.4 bar and that at the most favourable sprayer/sprinkler is not more than 3.5 bar, and that the velocity in distribution pipes shall not exceed 5 m/s.

Detailed hydraulic calculations in support of the above shall be submitted to the Authority for each zone. Orifice plates, if required, shall be fitted just above the deluge valves to keep pressures within the above limits. The aggregate pumping capacity shall be determined by the largest demand arising out of combination of deluge valves when zones concerned operate simultaneously.

8.2.7 Detection System (see also 9.15)

The installation and layout of detection system shall be governed by the layout of the water spray system.

The detection network shall be similar to the sprayer network and there shall be same number of detectors as there are number of sprayers. The detection piping shall be independently supported as far as possible and care shall be taken not to support other pipes on detection network. Where the building is divided into several zones, there shall be a cross zoning of detectors to enable simultaneous operation of all zones (see 8.2.6).

8.2.8 Supporting methods for pipes in case of both the detection and sprayers shall preferably be in accordance with 9.4 in all respects.

8.2.9 Pumping Capacity

Flow requirements as calculated in 8.2.6 shall be considered as total pumping discharge requirement and pump parameters shall be accordingly determined as per 10.1 (c) and Table 8.

8.2.10 Strainers

See 7.2.3 and 9.14.

8.2.11 Water Supply

See 11.1 and Table 9.

8.3 Horizontal Cylindrical Storage Tanks

8.3.1 Proposal for the protection of horizontal vessels shall be accompanied by full detailed dimensional working drawings showing the following:

- Plan, elevation and end view;
- Site plan showing the location of all vessels, their spacing, etc;
- The protuberances, such as valves, drains, manholes, flanges, ladders, supporting legs, etc;
- Bund area and product pipes within;
- Protection and detection piping in different colours; and
- Sprayers' characteristics showing the K-factor, cone angle and discharge, in lpm.

8.3.2 General Requirements

8.3.2.1 The complete exposed area of the horizontal storage vessel shall need to be protected at a uniform density of water application.

8.3.2.2 It is also necessary to protect the supporting legs and the product pipes within the bund area (if provided) by sprayers.

NOTES

1 Supporting steel members need not be protected if they are 300 mm or shorter in height.

2 Where tankage area is not provided with bund walls, product pipes within 15 m of tank shell shall be protected by the sprayers.

3 Also other occupancies, such as pump house, loading shed, etc falling within 15 m of the tank shell shall be protected by the sprayers.

8.3.2.3 The protection network shall be fabricated in the form of horizontal rows of sprayers connected by piping in rings. The number of rows required shall be governed by the diameter of the vessel in accordance with Table 3.

Table 3 Tank Diameter versus Number of Rows
(Clause 8.3.2.3)

Sl No.	Tank Diameter m	No. of Rows Required
(1)	(2)	(3)
i)	1.5 to less than 2.5	4
ii)	More than 2.5 to less than 3.5	5
iii)	More than 3.5	6

8.3.2.4 Sprayers shall be installed normal to the surface of the vessels so that their deflectors are at pre-determined distances of either 0.45 m or 0.55 m or 0.65 m from the skin of the vessels (see 8.3.2.3 and Table 4).

Table 4 Sprayer Selection
(Spray Angle versus K-Factor)
(Clause 8.3.2.4)

Sl No.	Distance Between Deflector and Shell Surface m	Rows	Sprayer Angle degree	K-factor Range
(1)	(2)	(3)	(4)	(5)
i)	0.65	4	90	26
			95	26-30
			100	28-38
			105	35-50
			110	40-60
			115	50-70
			120	60-80
		5	95	26
			100	30-35
			105	38-42
			110	40-60
			115	55-68
			120	56-80
		6	100	26-30
			105	34-38
			110	42-48
			115	52-58
			120	68-78

Sl No.	Distance Between Deflector and Shell Surface m	Rows	Sprayer Angle degree	K-factor Range
(1)	(2)	(3)	(4)	(5)
ii)	0.55	4	100	26-28
			105	26-35
			110	30-42
			115	35-50
			120	42-60
			125	52-75
		5	105	28-32
			110	32-38
			115	40-48
			120	48-62
			125	60-75
		6	105	26-28
			110	32-35
			115	38-45
			120	48-55
			125	52-72
iii)	0.45	4	115	26-35
			120	30-45
			125	35-55
		5	110	26-28
			115	28-35
			120	35-42
			125	42-50
		6	115	28-30
			120	32-38
			125	42-50

NOTES

1 For a chosen angle, if a sprayer with a matching K-factor is not available, next available K-factor shall be used.

2 Sprayer angle less than 90° and K-factor less than 26 shall be used only for local protections such as supporting legs, protuberances, etc.

3 Sprayers need not be installed normal to the surface for protecting the ends of the vessels.

8.3.2.5 The sprayers shall not be less than 6 mm in orifice size and shall normally have cone angles between 90° and 140°.

NOTE — Sprayers with cone angles below 90° and with K-factors less than 26 are permissible for local protections such as supporting legs, protuberances, etc.

8.3.2.6 Minimum and maximum pressures in the network shall be 1.4 bar and 3.5 bar, respectively.

8.3.2.7 'Run down' shall not be considered for horizontal vessels.

8.3.2.8 Adequate provision shall be made to promptly and effectively dispose of water discharged for firefighting, cooling, etc away from the vessels by any suitable means (*see* 9.10)

8.3.2.9 Vessels shall be spaced at more than 15 m from each other. In such cases, the water demand for the largest vessel shall determine the pumping and water requirements. If this is not followed, the aggregate water demand for all such vessels falling within the prescribed distance of each other shall be the determining factor.

8.3.3 Sprayer Network Design

8.3.3.1 Water shall be applied at a minimum density of 10.2 lpm/m² of the exposed area of the vessel. The supporting legs and product pipes within the bund shall also receive water at the same density.

NOTES

1 Supporting steel members need not be protected if they are 300 mm or shorter in height.

2 Where tank age area is not provided with bund walls, product pipes within 15 m of tank shell shall be protected by the sprayers.

3 Where high wind velocity is expected, for example, near sea coasts, the sprayers protecting the tankages shall be necessarily installed at 0.45 m from the surface of the vessels (*see* 8.3.2.4).

8.3.3.2 Number of rows shall depend on the diameter of the vessel and they shall be distributed equally around the circumference of the vessel (*see* 8.3.2.3).

8.3.3.3 Distribution of sprayers on each row

- Sprayers in horizontal rows shall be spaced at distances as detailed in Table 5 according to the angle selected (*see* also 8.3.2.3).
- As the sprayer application is based on distance between the deflector and the shell surface, number of rows, sprayer and K-factor range, the data available in Tables 3 and 4 shall be suitable used.

- To provide adequate protection to the ends of the vessels (varying types), the methods stated below shall be adopted.

Table 5 Longitudinal Spacing of Sprayer of Various Discharge Angles

[Clause 8.3.3.3 (a)]

Sl No.	Angle degree	Distance From Tank m		
		0.65	0.55	0.45
(1)	(2)	(3)	(4)	(5)
i)	60	0.90	0.80	0.70
ii)	65	1.00	0.85	0.70
iii)	70	1.05	0.90	0.70
iv)	75	1.15	1.00	0.85
v)	80	1.25	1.05	0.90
vi)	85	1.35	1.15	1.00
vii)	90	1.45	1.25	1.05
viii)	95	1.60	1.35	1.15
ix)	100	1.70	1.45	1.20
x)	105	1.85	1.60	1.30
xi)	110	2.00	1.70	1.45
xii)	115	2.20	1.90	1.55
xiii)	120	2.40	2.05	1.70
xiv)	125	2.65	2.25	1.90

8.3.3.4 Flat ended vessels

- Up to 5 m dia : The ends shall be adequately covered by half the flow from each end sprayer of all rows (*see* Fig. 3)
- More than 5 m dia : Arrangement as above plus an additional sprayer shall be located to aim on to the centre of the vessel (*see* Fig. 4)

8.3.3.5 Hemispherical ended vessels

- a) Up to 3.5 m dia : The ends shall be adequately covered by half the flow from each end sprayer of all rows plus one additional sprayer located to aim on the centre of the vessel.
- b) More than 3.5 m : Arrangement as above, plus additional sprayers to provide correct density.

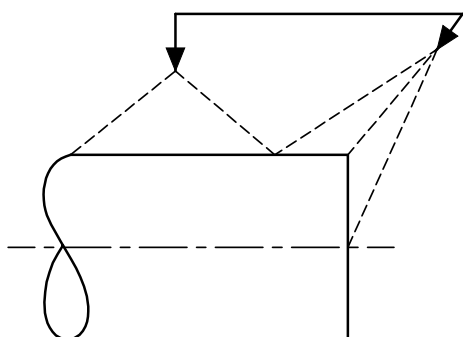


FIG. 3 FLAT ENDED VESSELS-COVERAGE OF TANK ENDS (UP TO 5 m DIAMETER)

8.3.3.6 Dished ended or average curved ended vessels

- a) Up to 3.5 m dia : The ends shall be adequately covered by half the flow from each end sprayer of all rows.
- b) Between 3.5 m and 5 m dia (see Fig. 8) : Arrangement as above plus an additional sprayer shall be located to aim on to the centre of the vessel.
- c) More than 5 m : Arrangement as in (b) above plus additional sprayers to provide correct density

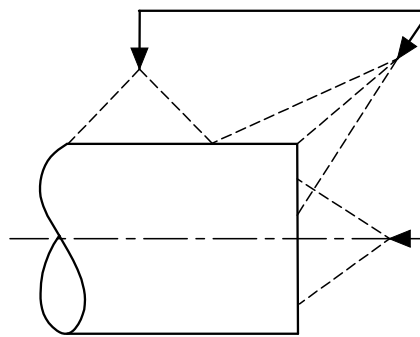


FIG. 4 FLAT ENDED VESSELS-COVERAGE OF TANK ENDS (ABOVE 5 m DIAMETER)

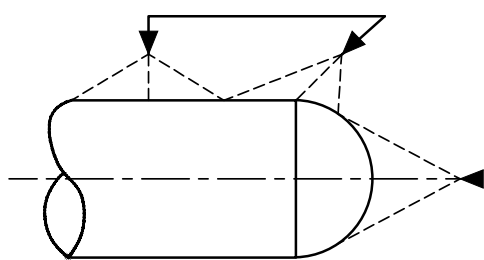


FIG. 5 HEMISPHERICAL ENDED VESSELS (UP TO 3.5 m DIAMETER)

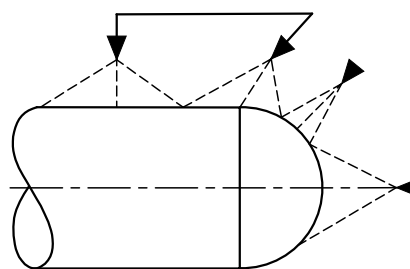


FIG. 6 HEMISPHERICAL ENDED VESSELS (ABOVE 3.5 m DIAMETER)

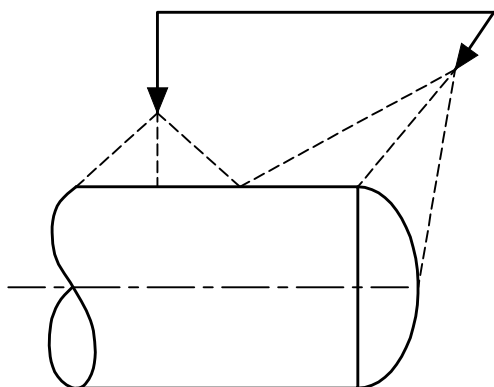


FIG. 7 AVERAGE CURVED ENDED TANKS
(UPTO 3.5 m DIAMETER)

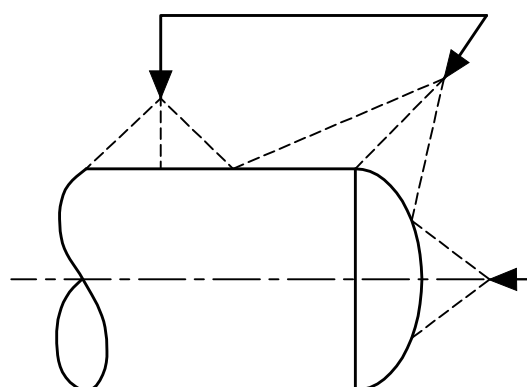


FIG. 8 AVERAGE CURVED ENDED TANKS
(ABOVE 3.5 m AND UP TO 5 m DIAMETER)

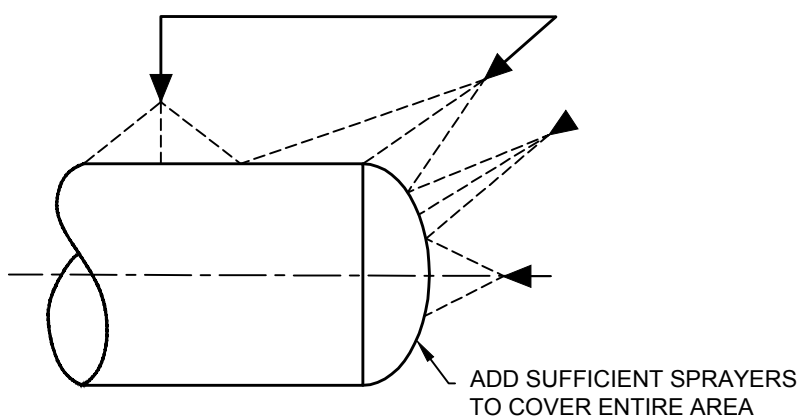


FIG. 9 AVERAGE CURVED ENDED TANKS
(ABOVE 5 m DIAMETER)

8.3.3.7 Separate sprayers shall be installed to provide wetting of all protuberances from the vessel, such as manholes, vents, flanges, relief valves, ladders, etc, in addition to the sprayers in rows and ends.

8.3.3.8 Un-encased steel supports for the vessels if exceeding 300 mm in height shall be wetted by individual sprayers.

NOTE — Concrete and encased steel supports need not be wetted separately as they are likely to be wetted by the splash of water spray for the vessels.

8.3.3.9 Spacing of sprayers for product pipes within the bund shall not exceed 3 m and sprayers shall be at a distance of not more than 800 mm from the pipes.

8.3.4 Piping Layout and Supports

8.3.4.1 The main feed pipes from the deluge valve feeding the network shall be supported at every 3.5 m of its run.

8.3.4.2 Vertical feed pipes shall be provided to establish flow from bottom rings to top rings at intervals not exceeding 3.5 m along the vessels. These pipes may also be used as supporting pipes for the network.

8.3.4.3 To ensure mechanical stability, good appearance and hydraulic gradient, the rings of pipe-work shall be of uniform size throughout each ring.

8.3.4.4 Where it is not possible to independently support the protection pipe-work, support can be arranged from the protected vessel if plate thickness of the vessel is adequate. In such case, synthetic elastomer insertion shall be provided beneath the base of support to accommodate curvature of the vessel and to prevent corrosion.

8.3.4.5 The sprayers in the bottom ring shall point 45° upwards and water in the pipe-work shall never drain through the sprayers.

8.3.4.6 Where vertical feed pipes are used for supporting the network, the pipes shall be braced together suitably at mid-heights to prevent buckling.

8.3.4.7 All vertical support pipes shall be fitted with non-ferrous or stainless steel cooling/drain/orifice plugs. The orifice diameter of hole in the plug shall not be less than 3 mm.

8.3.4.8 Vertical feed pipes, when used as supporting pipes, shall be flanged at the, base and bolted securely to the ground.

8.3.4.9 For vessels longer than 10 m in length, the network piping shall be so arranged that there is one feed pipe into the lower ring from the deluge valve for every 10 m and part thereof. It shall be ensured that each such segment serve an equal amount of protection for hydraulic balance.

8.3.5 System Hydraulics

The system shall be so designed that the hydraulically most unfavourable sprayer operates at a pressure of not less than 1.4 bar and the most favourable sprayer at a pressure of not more than 3.5 bar. Calculations along with nodal drawings shall be submitted to substantiate the above (see also 8.3.2.9).

8.3.6 Detection System

8.3.6.1 Detectors shall be installed in horizontal rows along the vessels and there must be same number of rows as for the sprayers.

8.3.6.2 Spacing of detectors on rows shall not exceed 2.5 m.

8.3.6.3 The detectors shall be located at not more than 1 m from the shell.

8.3.6.4 Separate detectors shall be provided for protuberances from the shell like manholes, flanges, etc.

8.3.6.5 Detectors shall be so positioned that they will not interfere with the spray pattern of the sprayers anywhere.

8.3.6.6 One central row of detectors shall be allowed for two vessels with longitudinal axes parallel provided guidance as in 8.3.6.3 is adhered to. However, the vessels concerned shall be wetted simultaneously during a fire.

8.4 Vertical Cylindrical Storage Tanks

8.4.1 Proposals for the protection of vertical vessels shall be accompanied by full detailed dimensional working drawings showing the following:

- Plan, elevation and end view.
- Site plan showing the location of all vessels, their spacing, etc.

c) The protuberances, such as valves, drains, manholes, flanges, ladders, supporting legs, etc.

d) Bund area and product pipes within.

e) Protection and detection piping in different colours,

f) Sprayers' characteristics showing the K-factor, cone angle and discharge, in lpm.

8.4.2 General Requirements

8.4.2.1 The complete exposed area of the vertical storage vessel shall need to be protected at a uniform density of water application.

8.4.2.2 It is also necessary to protect the product and pipes within the bund area (if provided) by sprayers.

NOTES

1 Where tankage area is not provided with bund walls, product pipes within 15 m of tank shell shall be protected by the sprayers.

2 Also other occupancies such as pump house, loading shed, etc, falling within 15 m of the tank shell shall be protected by the sprayers.

8.4.2.3 The protection piping network shall be fabricated in the form of horizontal rings at regular intervals and vertical feeder mains.

8.4.2.4 In case of vertical obstructions like wind girders, separate ring(s) shall be provided, if deemed necessary.

8.4.2.5 The conical/flat roof shall also be protected by water spray system. For this purpose, sprayers shall be connected through an explosion relief valve assembly, which enables sprayer piping on top of the vessels to be blown off in the event of an explosion without obstructing the sprayers cooling on the vertical sides.

8.4.2.6 Vertical mains shall be solely used as feeder mains only and sprayers shall be installed on the horizontal rings.

8.4.2.7 The sprayers shall not be less than 6 mm in orifice and shall normally have cone angles between 90° and 125° for vertical sides. For the conical roof/flat roof, wider angle sprayers with higher K-factor is recommended to reduce the number of sprayers and consequently the weight of piping over the tank.

NOTE — Sprayers with cone angles less than 90° and K-factors less than 26 are permissible for local protection such as protuberances. For product piping, it is permissible to use wide-angled sprayers more than 125°.

8.4.2.8 Minimum and maximum operating pressures in the network shall be 1.4 bars and 3.5 bars, respectively.

8.4.2.9 'Run down' shall be considered provided there are no obstructions on the sides. For this purpose, sprayers with reduced orifice size shall be acceptable in

the lower rings subject to maintaining uniform density all over (*see also 8.4.2.4*).

8.4.2.10 Sprayers shall be installed normal to the exposed area of the vessel and positioned at a distance of not less than 450 mm or more than 650 mm from the surface.

8.4.2.11 Vessels shall be located in individual dykes and spaced 15 m (or the diameter of the largest tank if the same is more than 15 m) apart. In such cases, the water requirement of the largest vessel shall determine the pumping and storage requirements.

However, if a number of tanks are located in a common dyke, the tanks located in a common dyke which have the largest aggregate shell surface area shall determine the pumping and storage requirements.

In case of tanks located in separate dykes, but within a distance of 15 m (or diameter of the larger tank is less than 15 m) of each other, the shell surface area of all such tanks shall determine the pumping and storage requirements.

NOTES

1 In case occupancies like pump house, loading sheds, etc, exist within 15 m (or the diameter of the largest tank as the case may be) of the vessels, such occupancies shall also be protected by sprayers.

2 Normally tanks with Class A and Class B liquids shall need to be protected with water spray systems. However, tanks containing other types of liquids if, located in a cluster along with tanks containing class A/class B liquids, shall also need to be protected with water spray system.

8.4.3 System Design

8.4.3.1 Density of discharge

Water shall be applied at a rate of not less than 10.2 lpm/m² of the exposed area of the tank shell and the roof. The product pipes within the bund shall also receive water at this density.

NOTES:

1 Supporting legs, if any, shall also receive water at the same density irrespective of whether they are insulated or not.

2 *See 8.4.2.2.*

8.4.3.2 Distribution of sprayers

Sprayers shall be spaced at not more than 2.5 m in the rings when measured along the curved surface of the vessels. There shall be a ring for every 3.5 m height of the shell (*see also 8.4.2.4*). Due diligence shall be exercised about the presence of wind girders and if there are more wind girders, at least one ring shall be available between the girders subject to 3.5 m distance.

Sprayers in each successive ring shall be staggered for better coverage. Sprayers protecting the roof must be located in such a way that the extremities of their spray pattern shall at least meet. Separate sprayers shall be installed to provide wetting of all protuberances from the vessels, such as manholes, flanges, ladders, vents,

etc. Spacing of sprayers for product pipes within the bund shall not exceed 3 m and sprayers shall be at a distance of not more than 800 mm from the pipes (*see also note under 8.4.2.7*).

8.4.4 Piping Layout and Supports

The main feed pipes from the deluge valve feeding the network shall be supported at every 3.5 m of its run. The number of vertical feeders for the sprayer network depends upon the size of vessel and its height. As a good practice, minimum of two such feeders shall be provided. However, for the vessels less than 10 m diameter and height, one feeder shall be accepted. The top ring shall be installed just below the top of the vessel and the bottom ring shall be installed at not more than 2 m from the ground level. The rings may be supported on the vessel if plate thickness of the vessel is adequate.

The vertical feed mains shall also be used as supporting pipes. These pipes shall be flanged at the base and bolted securely to the ground. The sprayers at the bottom ring shall point slightly upwards and water in the pipe work shall never drain through the sprayers. All support pipes shall be fitted with non-ferrous or stainless steel cooling/drain orifice plugs. The orifice size of the hole in the plug shall not be less than 3 mm.

8.4.5 System Hydraulics

The network shall be hydraulically so designed as to provide a minimum running pressure of 1.4 bar at the hydraulically most un-favourable sprayer and not more than 3.5 bar at the hydraulically most favourable sprayer in the network (*see also 8.4.2.11*). The velocity in the feeder pipes shall not exceed 5 m/s when sprayers discharge at their nominal rates.

Detailed hydraulic calculation along with nodal drawings shall be submitted supporting the design. Orifice plate shall be provided, if required, above the deluge valves to meet the conditions as above. Flow through the cooling/draining pipes shall also be considered for the hydraulic calculation.

8.4.6 Detection System

Detectors shall be installed in horizontal rings supported on the spray network if necessary. Provision of detectors in rings shall comply with the following:

- a) *Fixed roof tanks located in separate dykes* — There shall be at least two rings of detectors, one at the top where the conical roof rests and one at the bottom within 1 m from the bottom of the tank plate.
- b) *Fixed roof tanks located in a cluster within a single dyke* — There shall be an additional ring over and above what is suggested in (a) in the centre of the tank height.
- c) *Floating roof tanks containing class A liquids* — There shall be at least two rings of detectors one

near the top of the tank and one at the bottom within 1 m from the bottom of the tank plate subject to the condition that detection of fire from the mandatory automatic foam system (rim seal protection), triggers the water spray system also through alarm system interface.

- d) *Floating roof tanks containing other than class A liquids* — There shall be at least three rings of detectors, one each at the top of the tank, one at the bottom of the tank plate and it is strongly advised to provide one at the centre of the tank height (see Note 2 under 8.4.2.11)
- e) *Fixed and floating roof tanks* — In all the cases discussed above, spot detectors shall be provided for all the protuberances where applicable like, manholes, vents, flanges, relief valves, etc, on the conical roof as well on vertical sides.

The spacing of detectors in rings shall not be at more than 3 m when measured along the curved surface of the vessel. For conical roof the detector shall be installed on 9 m² area basis. The detectors shall be located at not more than 1 m from the shell. Separate detectors shall be provided for protuberances like manholes, flanges, etc. Detectors shall be so positioned as not to interfere with the sprayer pattern of the sprayers anywhere. Floating roof tanks storing class A and B liquids shall, in addition to the detectors as stated above, shall be provided with suitable detection facilities at the floating rim seal like linear heat sensing cables as per IS 2189.

8.5 Protection of Spherical Vessels

8.5.1 Drawings

8.5.1.1 Proposals for the protection of vertical vessels shall be accompanied by full detailed dimensional working drawings showing the following:

- a) Plan, elevation and end view;
- b) Site plan showing the location of all vessels, their spacing, etc.;
- c) Protuberances, such as valves, drains, manholes, flanges, ladders, supporting legs, etc;
- d) Bund area and product pipes within;
- e) Protection and detection piping in different colours; and
- f) Sprayers' characteristics showing the K-factor, cone angle and discharge in lpm.

8.5.1.2 Spherical vessels are almost certain to be pressure vessels. The complete exposed area sphere shall need to be protected at a uniform density of water application.

8.5.1.3 It is also necessary to protect the supporting legs and the product pipes (for a distance of at least 15 m from the surface of the sphere) by the water spray system at the same density.

8.5.1.4 The protection network around such vessels shall be fabricated in the form of horizontal and/or vertical rings at regular intervals.

8.5.1.5 The sprayers shall not be less than 6 mm in orifice size for spheres upto 12 m diameter and more than 6 mm for those having diameters more than 12 m. The sprayers shall normally have cone angles between 90° and 125° for covering the spherical surface.

NOTE — Sprayers with cone angles less than 90° and K-factors less than 26 are permissible for local protection such as protuberances. For product piping, it is permissible to use wide-angled sprayers, than 125°.

8.5.1.6 Minimum and maximum pressures in the network shall be 1.4 bar and 3.5 bar, respectively.

8.5.1.7 'Run down', shall not be considered.

8.5.1.8 Sprayers shall be normal to the exposed surface of the sphere and shall be installed at not less than 550 mm or more than 650 mm from the surface.

8.5.1.9 Spheres shall be spaced at a distance of minimum 15 m from each other. In such cases the water demand for a larger sphere shall determine the pumping and storage requirements. If the spheres are spaced less than 15 m apart, the aggregate water demand of all the spheres falling within the prescribed distance of each other shall be the determining factor for hydraulic calculations.

8.5.2 System Design

8.5.2.1 Density of discharge

Water shall be applied at a minimum density of 10.2 lpm/m² of the exposed area of the sphere. The supporting legs and the product pipes within the bund area shall also receive water at the same density. Where bund is not provided, the product pipelines up to a distance of 15 m from the surface of the sphere shall receive water at the same density.

NOTES

1 If the supporting legs are encased with 50 mm thick RCC, the water density, therefore, can be reduced to 5.1 lpm/m².

2 Selection of sprayers and pipe sizes shall be in such a way as to avoid overspray on the sphere surface and the achieved density should be preferably within 20 percent of the design density as above.

8.5.2.2 Distribution of sprayers and layout of piping

The following considerations shall be made:

- a) No sprayer shall be farther than the distance 'S' indicated in Fig. 10, from anyone of the nearest 8 sprayers. The distance between sprayers shall be measured along the arcs between the points of impingement of the sprayers on the tank surface.
- b) The spacing 'S' between the sprayers for various diameters of the sphere for different cone angles of

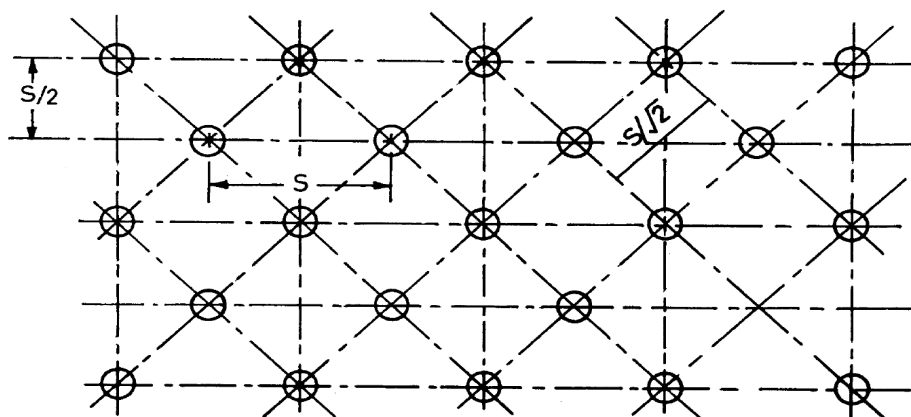


FIG. 10 SPACING OF SPRAYERS

sprayers shall be selected based on the following parameters:

- 1) Manufacturer's recommendation and the spray pattern provided by them.
- 2) Total exposed surface area of the sphere shall be impinged without any possibility of hotspots.
- 3) The spray pattern shall overlap on the surface of the sphere by at least 5 percent.
- c) Obstructed or 'roofed off' portions of the spheres shall be protected with separate sprayers in addition to the requirements under **8.5.2.2** (b) above at a density of 10.2 lpm/m².
- d) Number of horizontal and/or vertical rings shall be governed by the spacing of the sprayers [see **8.5.2.2**(b)].
- e) The system shall be hydraulically designed in such a way that the pressure at the hydraulically most unfavourable sprayer shall not be less than 1.4 bar while that at the hydraulically most favourable sprayer shall not exceed 3.5 bar. The difference in height between the top and bottom sprayers may be compensated for by reducing sprayer orifice and/or other means to achieve even distribution of water on the surface. The velocity produced in the feeder pipes shall not exceed 10 m/s.
- f) Cooling system for protecting the sphere against solar heating shall take the form of minimum two rings of sprayers at the top of the spheres upto 10 m diameter and three rings of sprayers at the top of the sphere exceeding 10 m diameter at a density not less than 2 lpm/m².

NOTE — It is not considered necessary to wet the surface of the sphere below the horizontal centre line when considering solar protection.

- g) Spacing of sprayers for the product pipelines shall not exceed 3 m and sprayers shall be at a distance of not more than 800 mm from the pipes (see also **8.5.1.5**).

8.5.3 Pipe Support

8.5.3.1 The pipe work on the top of hemisphere of the vessel shall rest on the surface and an adequate number of support points shall be required to distribute the weight uniformly on the surface.

8.5.3.2 The pipe work below the hemisphere shall be supported separately from the ground or the legs supporting the sphere. The legs shall be designed to take care of this load.

8.5.3.3 Where supports rest on the surface of the sphere, synthetic elastomer insertion shall be provided beneath the base of the support and the sphere surface to accommodate the curvature of the sphere as well as to prevent corrosion.

8.5.3.4 Where the vessel is insulated, supports shall have to either penetrate the lagging or provided on the lagging itself. In either case, greater care shall have to be taken to adequately spread the load and efficiently seal the penetrated area of the lagging after supports are installed.

8.5.4 Detection System

8.5.4.1 It is not necessary to provide detector sprinklers for the whole surface of the sphere. Detectors at three levels shall suffice as follows:

- a) A minimum of three under the lower pole adjacent to product piping.
- b) A ring of detectors at the equator or just below. The detectors shall be installed at not more than 2.5 m of the circumference of sphere.
- c) A minimum of three detectors at the upper crown of the sphere in the advantageous position near relief valves, vents, etc.
- d) All protuberances on the sphere shall be separately provided with individual detectors.

8.5.4.2 The detector shall be suitably supported, if required on sprayer piping.

8.5.4.3 The detector shall, in any case, be installed at not more than 300 mm from the surface protected.

8.5.4.4 Detectors shall also be installed near the product pipes at every 2.5 m and at least up to 15 m from the shell surface of the sphere.

8.5.5 Pumping Capacity

The aggregate pumping capacity shall be determined by the largest demand arising out of one or more of deluge valves when vessels concerned operate simultaneously [see 11.1 (c) and Table 9].

8.5.6 Water Supply

See 11.

8.6 Tunnels, Cable Galleries and Cable Cellars

8.6.1 General

8.6.1.1 Where cable fires are concerned, the greatest hazard usually arises from the effects of fire on the power station plant. However, a feature of practically all cable fires has been that several units, if not the whole station, has been seriously affected by a single fire. A major portion of cable fire incidents stem from external sources such as combustion of un-cleaned flammable debris, accumulation of PVC tailing ends, cardboard packages and from uncontrolled spillages, over spray of fuel and lubricating oils.

8.6.1.2 PVC is not readily flammable but will burn freely in temperature conditions high enough to bring the plasticisers into a volatile state. Burning PVC produces copious quantities of dangerous hydrochloride toxic gases, which are heavier than air and tend to form layers at lower levels. These gases are corrosive and present a major toxic hazard to operating and firefighting personnel. When PVC is burnt, heavy black smoke, mostly consisting of carbon particles, is given off which could affect electrical equipment some distance from the fire and there is some evidence that PVC smoke can de-sensitise smoke detectors of ionisation chamber type.

8.6.1.3 Cables are normally protected such that they do not catch fire if electrical faults develop in them. However, the energy released when a fault occurs in a cable may ignite other combustible materials in the vicinity thereof.

8.6.2 Design Density

Water shall be applied at a minimum density of 10.2 lpm/m² of the exposed area of the cable racks.

NOTE — For the purpose of the above, three cable trays of a rack shall be reckoned as a single tray unless the trays are not of the same width in which case the area of the widest tray shall be taken (see also 8.6.4.5).

8.6.3 Pressure Requirement

In order to achieve a better penetration, a minimum pressure of 2.1 bar shall be achieved at the hydraulically remotest point.

8.6.4 Distribution of Sprayers and Layout of Piping

8.6.4.1 The sprayers shall be installed in rows at ceiling level in between and at the centre of aisle space along the cable trays and spaced at not more than 3 m.

8.6.4.2 The distance between walls and/or limits of the protection shall not exceed 1.5 m.

8.6.4.3 Where the distance between two rows of sprayers above the aisles exceeds 4 m, additional row of sprayers shall be provided (see 8.6.4.1).

8.6.4.4 Where the height of the cable trays (that is, distance between topmost and bottom tray) exceeds 2.5 m, sprayers shall be provided below the lowest tray.

8.6.4.5 When the cable racks contain more than three trays, system protection shall be designed as follows (see also 8.6.2):

- a) Protection shall be extended to cover every three trays (below the top three) or part thereof by dropping pipes from the sprayer network at roof level.
- b) Sprayers shall be so installed that their pattern covers all the three trays and water can penetrate inside to provide adequate protection to the cables.
- c) Sprayers shall be spaced at a minimum of 2.5 m along the longitudinal side of the cable racks.
- d) Sprayers and the piping shall be suitably supported to avoid oscillation and protected against possible mechanical damage.

8.6.5 System Hydraulics

8.6.5.1 Installation of piping shall be carried out, in general, as detailed in 9.3 to 9.7.

8.6.5.2 It is permissible to divide the protection area into several zones, each of which shall be fed by an individual deluge valve. Each zone shall not exceed 30 m length. The flow through the deluge valve shall be limited to the values in Table 7. The system shall be designed in such a way that at least two zones shall operate simultaneously in the event of fire.

8.6.5.3 Each zone in the system shall be hydraulically so designed that a minimum pressure of 2.1 bar is available at the remotest sprayer and maximum pressure in the installation shall not exceed 3.5 bar. Velocity produced in the feeder pipes shall not be more than 10 m/s.

8.6.5.4 Detailed hydraulic calculations along with nodal drawings in support of the above shall be submitted for each zone. Orifice plates, if required, shall arise out of

combination of deluge valves when zones concerned operate simultaneously.

8.6.6 Detection System

8.6.6.1 As the cable galleries and tunnels are normally unmanned, it is imperative that a quicker detection is mandatory to ensure extinguishment. Various types of detectors are available for installation in the tunnels. The following methods of detection in the order mentioned are generally accepted. The installation shall comply with various provisions of IS 2189 and IS 15105, where applicable:

- a) Linear heat sensing cables;
- b) Smoke detectors; and
- c) Sprinkler heads.

8.6.6.2 Full details of the proposal shall be submitted to the authorities concerned in advance along with detailed drawings showing the location and layout of the detection network.

8.6.6.3 The fire alarm system and panel shall be of approved type and in compliance with IS 2189 and IS 15908, where applicable.

8.6.6.4 Authorities concerned can accept other types of detectors, which may be subject to verification of the proposals submitted in advance.

8.6.7 Pumping Capacity

The aggregate pumping capacity shall be determined by the largest demand arising out of combination of deluge valves when zones concerned operate simultaneously.

8.6.8 Water Supply

See 11.

8.7 Conveyors

8.7.1 General

8.7.1.1 Fires on conveyors are infrequent but the fire potential is considerable. In incidents which have occurred, the damage has been severe, particularly where conveyor fires have reached and enveloped the destination for example, boiler house, coal bunkers as in case of thermal power stations. The design of conveyors is that the wind tubular or chimney effect is an inherent feature on inclined conveyors and this causes rapid spread of fire through the conveyors.

8.7.1.2 The major risk of fire is for example, from the ignition of coal dust and deposits in case of thermal power stations, on the internal surface, walkways, etc, of the conveyors or from the conveyor belt. Fire caused by friction of a defective part such as jammed roller, idlers resulting in subsequent localised overheating of the belt. Thus fires in the conveyors may arise from

either of two main causes:

- a) Failure of part of the mechanism, usually on the idler or pulley can lead to localised overheating of the belt and eventually to ignition of the combustible dust or conveyor belt; and
- b) From the ignition of a quantity of split combustible dust either by self-ignition or other causes.

8.7.1.3 Should the belt catch fire, it can spread the fire rapidly to other areas. Certain fires generate a large volume of smoke, particularly when the fire is in an advanced state conveyors can be protected by automatic sprinkler system installation or medium velocity water spray system with linear heat sensing (LHS) cables, sprinkler bulbs, thermocouples, etc, and the following provisions cover requirements for water spray system only.

8.7.2 Design Density

Water shall be applied at a minimum density of 10.2 lpm/m² of the exposed area of the conveyor.

8.7.3 Pressure Requirement

A minimum pressure of 1.4 bar shall be achieved at the hydraulically remote sprayer. However, pressure at the hydraulically favourable sprayer shall not exceed 3.5 bar.

8.7.4 Distribution of Sprayers and Layout of Piping

8.7.4.1 The sprayers shall be installed in rows at the ceiling level above the centre of each conveyor belt and spaced at not more than 4 m.

8.7.4.2 The distance between walls and/or limits of the protection shall not exceed 2 m.

8.7.4.3 Where the distance between two rows of sprayers above the centre of belts exceeds 4 m, additional rows shall be provided.

8.7.4.4 Sprayers shall be provided for the protection of the bottom side of the conveyors and these shall be spaced at 4 m on either side of the conveyor. Staggering of sprayers is recommended.

8.7.4.5 Area covered by each sprayer shall not be more than 12 m² or less than 9 m².

8.7.5 System Hydraulics

8.7.5.1 Installation of piping shall be carried out in general as detailed in 9.3 to 9.7.

8.7.5.2 It is permissible to divide the protection area into several zones, each of which shall be fed by an individual deluge valve. The flow through the deluge valve shall be limited to those given in Table 7. The system shall be designed in such a way that at least two adjacent zones shall operate in the event of fire.

8.7.5.3 Each zone in the system shall be hydraulically so designed that a minimum pressure of 1.4 bar is available at the remotest sprayer and that nowhere in the system exceeds 3.5 bar. The velocity produced shall not exceed 10 m/s.

8.7.5.4 Detailed hydraulic calculations along with nodal drawings in support of the above shall be prepared for each zone. Orifice plates, if required, shall arise out of combination of deluge valves when zones concerned operate simultaneously.

8.7.6 Pumping Capacity

The aggregate pumping capacity shall be determined by the largest demand arising out of combination of deluge valves when zones concerned operate simultaneously.

8.7.7 Water Supply

See 11.

8.7.8 Detection System

8.7.8.1 Detection of conveyor fires poses peculiar problems as the fires are not always stationary. Detection of moving fires shall be achieved without delay. The detectors upon sensing the fire shall trip the conveyor motor first and thus make the fire stationary. This fire has to be detected and the detectors shall trigger the firefighting operations. Hence, there are two levels of detection for the conveyor fires. The following methods of detection are generally acceptable:

- a) Liner heat sensing cables for stopping conveyor, and
- b) Sprinkler bulbs.

8.7.8.2 Full details of the protection shall be submitted to authorities concerned in advance along with detailed drawings showing the location and layout of the detection network.

8.7.8.3 The fire alarm system and panel shall be of approved type in accordance with IS 2189 and IS 15105, where applicable.

8.7.8.4 Authorities concerned reserve their right in accepting other types of detectors, which is subject to verification of the proposals well in advance.

9 COMPONENTS OF SPRAY SYSTEM INSTALLATION

9.1 Piping

9.1.1 Underground Pipes

The pipe used in the spray system (from the pump house to the deluge valves) shall be laid underground or in masonry culverts with removable covers of

incombustible construction and shall be of any one of the following types:

- a) Cast iron double flanged class 'A' pipes conforming to the following standards:

<i>Sl No.</i>	<i>Title</i>	<i>IS No.</i>
i)	Horizontally cast iron pipes	IS 7181
ii)	Vertically cast iron pipes	IS 1537 ¹⁾
iii)	Centrifugally cast (spun) iron pipes	IS 1536
iv)	Centrifugally cast (spun) iron pipes, class A with rubber gasket (<i>Tyton</i>) joints	IS 1536
v)	Centrifugally cast (spun) ductile iron pipes	IS 8329
vi)	Electric resistance welded (ERW) steel pipes	IS 3589 Heavy grade ²⁾
vii)	Wrought or mild steel pipes (non-galvanized) of heavy grade	IS 1239 ²⁾
viii)	Wrought or mild steel pipes (galvanized) of heavy grade	IS 10748 ³⁾

¹⁾ Where the nominal diameter of the pipe exceeds 300 mm or where the pump delivery pressure exceeds 7 bar, class B pipes would be necessary.

²⁾ Welding permissible with welded joints and coated and wrapped as per IS 10221. At least 10 percent of all the welded joints shall be radiographically tested and half of the joints radiographed shall be field joints. It is strongly recommended to subject the pipes to cathodic protection to ensure longevity of the piping installation.

³⁾ No welding is permissible.

9.1.2 Above Ground Pipes

- a) Electric resistance welded : IS 3589 (ERW) steel pipes of heavy grade
- b) Wrought or mild steel pipes : IS 1239 (non-galvanized) of heavy grade (Parts 1 and 2)
- c) Wrought or mild steel pipes : IS 10748 (galvanized) of heavy grade

9.1.3 The pipe used in the spray system (from the pump house to the deluge valves) can also be laid above ground in case of piping materials as per 9.1.2 with welded [except in case of 9.1.2(c)], threaded or flanged or grooved joints subject to following conditions:

- a) Pipes shall be laid in exclusive steel supports and shall not run in pipe racks with other utility piping.

- b) The pipes shall be run at minimum distances as stated below:

- 1) Light hazard : 6 m
- 2) Ordinary hazard : 6 m
- 3) High hazard (including open storage) : 15 m

9.1.4 Pipes shall not be laid under buildings or plant areas or storage areas. As far as possible, pipes shall not be laid under large open storage, railroads and roads carrying heavy traffic.

9.1.5 Underground pipes shall be laid not less than 1 m below ground level. Pipes running under roads shall be routed through home pipes to avoid damage to the pipes due to traffic and vehicle movement.

9.1.6 Underground pipes in case of materials in **9.1.1** shall be provided with masonry or equivalent supports and thrust blocks (where necessary) at regular intervals.

9.1.7 Where soil conditions are unsatisfactory, masonry or equivalent supports shall be provided at regular intervals for all other pipes also.

9.1.8 Pipes shall not traverse on ground, which is not under the control of the owner of the installation. Pipes shall also not pass through public roadways.

9.1.9 The installation piping (from the pump house upto deluge valve and also the installation piping with sprayers above the deluge valve) shall be capable of withstanding for 2 h a pressure equivalent to 150 percent of the maximum working pressure.

9.1.10 All bolt holes in the flanges shall be drilled. Drilling of each flange shall be in accordance with the relevant Indian standards.

9.1.11 Flanges shall be faced and have jointing of rubber insertions or asbestos compound.

9.1.12 Welded joints of any type shall not be permitted for pipes having diameter less than 50 mm.

9.1.13 It is not permissible to run the spray system pipes through a building or occupancy (not protected by sprinkler or spray systems) and where it is not practicable, the supply pipeline shall be installed at ground level and enclosed in brick trenches covered with removable RCC precast slabs.

9.1.14 All installation pipework above ground shall be installed at a slope not less than 1 : 500 for horizontal run of pipes. Normally the pipework should slope through the deluge valve. If the pipework is trapped (below the level of the deluge valve for example, in the basements), arrangements shall be made to provide drain cocks at the bottom of such pipes to drain the trapped water.

9.1.15 Sprayer pipes shall not be embedded in concrete floors or ceilings of any building.

9.2 Fittings

9.2.1 Fittings installed underground shall be of cast iron heavy grade conforming to IS 1538 whereas those installed over ground shall be of medium grade wrought or mild steel conforming to IS 1239 (Part 2) or malleable iron fittings conforming to IS 1879 or IS 9523 for ductile iron fittings.

9.2.2 All fittings shall be able to withstand at least a pressure of 150 percent of the maximum working pressure.

9.2.3 Welded fittings according to the laid down welding procedure are permitted. Welded parts shall be galvanized or suitably coated after welding as per the requirement of the areas to be protected by the system that is, chemical and electrolytic corrosion.

9.2.4 Welded joints shall not be permitted for fittings of less than 50 mm diameter.

9.2.5 Grooved couplings including their gaskets used in water spray systems shall be approved for use in dry systems.

9.3 Joining of Piping and Fittings

9.3.1 Threaded Pipes and Fittings

- a) All threaded pipes and fittings shall have threads cut as per relevant Indian Standards.
- b) Steel pipes with thicknesses less than schedule 30 (size 200 mm or more) and those of schedule 40 (size less than 200 mm) shall be permitted to be jointed only with threaded fittings.
- c) Joint compound or tape shall be applied only to male threads.

9.3.2 Welded Pipe and Fittings

Pipes meant for spray installation shall only be shop welded, unless permitted by the authorities or agencies responsible for approval of the spray system. Welding shall be done under supervision as per proper approved procedures through qualified welders. Necessary records shall be maintained with regard to work completed, defects observed, re-work and clearance, etc. Also details of radiography test for the welded pipes duly signed by the protocol shall be maintained.

9.3.3 Groove Joining Methods

Pipes joined with grooved couplings shall be joined by approved couplings, gaskets and groove dimensions. Grooved connections of fittings and valves and grooves cut and rolled on pipe shall be dimensionally compatible with the couplings.

9.4 Pipe Supporting Methods (Above Deluge Valve)

9.4.1 General (Building or General Area Protection)

Sprayer pipes shall be supported from the building structure which, itself shall be capable of supporting the water filled pipework and shall not impair the performance of sprayers under fire conditions. Pipework shall not be used to support any other loads except where primary support is designed for the suspension of the piped service. Distribution/range pipes shall not be supported from ceiling sheathing or cladding or from any other associated suspension systems. Pipes below obstructions, such as, ductwork shall be either supported from the building structure or from the steel members supporting such obstructions. Such members shall be capable of supporting the weight of water filled pipes too.

Hangers shall not be welded or fastened directly to the pipework. The supports on which the pipework rests shall be secured firmly in position. The thickness of all parts of pipe supports shall not be less than 3 mm. Wherever possible, pipes shall be supported from non-combustible building elements. Pipework in corrosive areas shall be of either stainless steel or suitably protected against corrosion. The distance between the pipe supports measured along the line of connected pipes (whether the pipes run horizontally, vertically or at angles) shall not be less than that given in Table 6.

Table 6 Distance Between Pipe Supports
(Clause 9.4.1)

Sl No.	Pipe Diameter mm	Spacing m
(1)	(2)	(3)
i)	Up to 65	4
ii)	More than 65 and up to 100	6
iii)	More than 100 and up to 250	6.5

9.4.2 Distribution Pipes

The first support on a nominally horizontal distribution pipe shall not be at more than 2 m from the main distribution pipe. The last support on a nominally horizontal distribution pipe shall not be more than 450 mm from the end. Drop or rise pipes shall be secured to the building structure either directly or indirectly at the adjacent nominally horizontal part of the pipe within 300 mm of the drop or rise.

9.4.3 Range Pipes

At least one support shall be provided for:

- each pipe run connecting adjacent sprinkler, and
- the pipe run connecting the distribution pipe and the first sprinkler on the range pipe.

9.4.3.1 Pipe supports shall not be closer than 150 mm to any sprinkler axial central line. The first support on a range pipe shall not be more than 2 m from the distribution pipe. The last support on a range pipe shall not be located more than 1.5 m from,

- the range pipe end;
- where there is a horizontal arm pipe of 450 mm or longer, the arm pipe end; or
- where there is a drop or rise exceeding 600 mm, the drop or rise pipe end.

9.4.4 Outgoing mains from the installation valve to the system shall be supported at every 3.5 m of its run.

9.4.5 The thickness of all components used in pipe supports shall not be less than 3 mm anywhere.

9.4.6 Some of the typical supporting arrangements are shown in Fig. 11.

9.5 Protection against Fire and Mechanical Damages

Piping shall be installed in such a way that the pipes are not exposed to mechanical damage. Where pipes are installed above gangways with low headroom or at intermediate levels or in other similar situations, precautions shall be taken against mechanical damage.

Where it is unavoidable for water supply pipework to pass through a building or occupancy (not protected by sprinkler or spray systems), it shall be installed at ground level and shall be enclosed to protect against mechanical damage, with appropriate fire resistance.

9.6 Painting

Non-galvanized ferrous pipework shall be painted if environmental conditions make it necessary. Galvanized piping shall be painted wherever the coating has been damaged for example, by threading.

9.7 Drainage (Pipelines)

Means shall be provided to enable all the pipework to be drained. Where this cannot be done through the drain valve at the deluge valve, extra valves shall be fitted as specified in 9.9.3. Range pipes shall have a slope towards the distribution pipe of at least 0.4 percent and distribution pipes shall have a slope towards the appropriate drain valve of at least 0.2 percent. Range

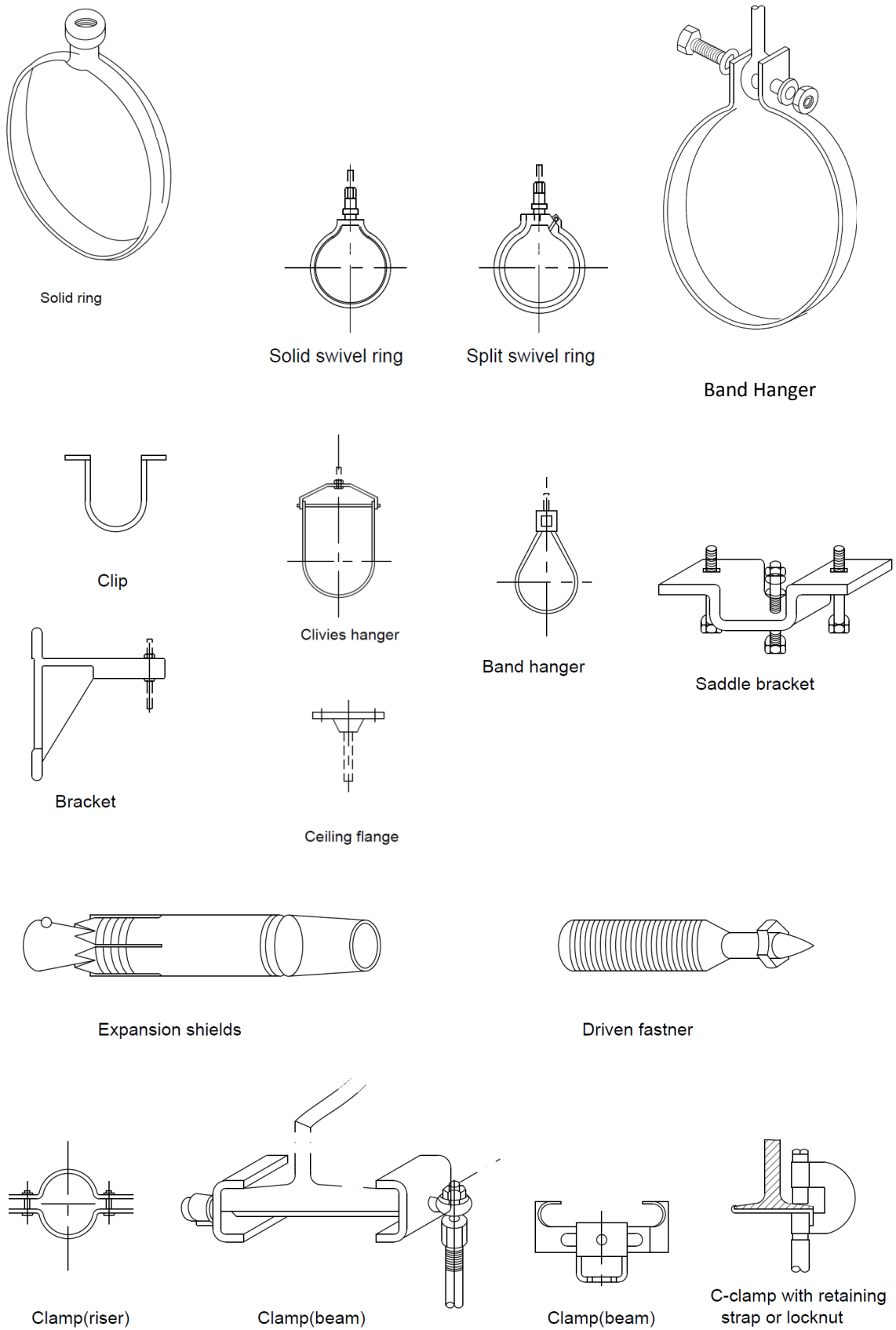


FIG. 11 TYPICAL SUPPORTING ARRANGEMENTS

pipes shall only be connected to the side or top of distribution pipes.

9.8 Valves

9.8.1 General

The various types of valves used in the installation are stop valves, drain valves, and deluge valves. All stop valves which may cut off water supply to the sprinkler installation shall,

- a) close in the clockwise direction;
- b) be fitted with an indicator that clearly shows whether it is in the open or closed position; and
- c) be secured in the right position by a strap and padlock or secured in an equivalent manner.

Butterfly valves, if used, shall be of the gear operated type for sizes more than 150 mm and motor operated if more than 300 mm (see IS 13095). Valves which interlock when closed shall be positioned in a conspicuous place where the key is obtrusive when the valve is closed.

9.8.2 Main Stop Valves

Where spray systems are fed by a ring main supply pipe arrangement on the premises stop valves shall be installed to isolate the ring into sections in such a way that no section shall include more than 3 deluge valves. The main stop valve(s) shall be at a fire brigade access level and readily accessible when responding to a fire alarm. Where the working pressure of the installation is more than 7 kg/cm² cast iron valves with PN 1.6 rating (nominal pressure) shall be provided. However, cast steel valves of class 150 shall suffice for installation under all pressure conditions.

9.8.3 Drain Valves

Drain valves sized as below shall be fitted to allow drainage from:

- a) Immediately downstream of the installation alarm valve or, if fitted, its downstream stop valve;
- b) Immediately downstream of any stop valve;
- c) Any pipe other than drop pipes to single sprayers which cannot be drained through another drain valve;
- d) Valves shall be fitted at the lower end of permanent pipework. The outlet shall be not more than 3 m above the floor and shall be fitted with a brass plug; and
- e) Where it is not possible to drain the water from a distribution or range pipe, drain pipes shall be provided as stated below:
 - 1) Trapped distribution pipes : 40 mm
 - 2) Trapped range pipes : 25 mm

9.9 Deluge Valves

9.9.1 A deluge system is a fixed fire protection system which totally floods an area with pressurized water through a system of piping with open nozzles and/or sprinklers. The system piping is empty until the controlling valve is activated by pneumatic or other types of release systems. Such controlling valves which are quick opening in nature are called 'deluge valves'. The deluge valve assembly consists mainly of the following:

- a) In line strainer;
- b) Isolation valve;
- c) Deluge valve;
- d) Drain valve;
- e) Pressure gauges (above and below the deluge valve);
- f) Alarm assembly (consisting of gong or sounder); and
- g) Actuator/pilot assembly.

9.9.2 Varieties of deluge valves with different working principles are available and hence it is necessary that the valves shall have approval from national/international approving bodies.

9.9.3 Principle of Operation

The deluge valve has an inlet, outlet and priming chamber. The inlet and outlet are separated from the priming chamber by the valve chamber and diaphragm. In the 'SET' position, pressure is applied to the priming chamber through a restricted prime line. The pressure is trapped in the priming chamber and holds the clapper/diaphragm on the seat due to the differential design. In the set position, the clapper/diaphragm separates the inlet from the outlet keeping the system piping dry. When the pressure is released from priming chamber faster than it is supplied through the restricted priming line, the clapper moves and allows the inlet water supply to flow through the outlet into the system and associated alarm device.

The mode of actuation of deluge valve can be pneumatic or hydraulic type or a combination of both.

9.9.4 Requirements of Installation

The following lists the necessary requirements to ensure proper installation:

- a) Deluge valve shall be installed outside of but adjacent to the protected area as close to the risk as possible but at not less than 6 m from the plant and/or equipment to be protected.
- b) Masonry enclosures shall be provided around the deluge valve in the form of barrier walls in such a way that the valve is not exposed to any

impact due to flying bodies or projectiles from the plant and/or equipment in the vicinity and also for weather protection.

- c) Isolating valves shall be provided below the deluge valves to enable servicing thereof and cleaning strainers at regular intervals.
- d) Isolating valves shall be provided above the deluge valve in addition, for testing purposes.
- e) The isolating valves shall be strapped and locked in open position by leather straps or nylon chains and pad locks under normal operating condition.
- f) Emergency manual override facility shall be provided for actuating the deluge valve.
- g) It is permissible to provide a manually operated bypass line with an isolating valve for emergency requirements. Such valves shall always be kept locked in closed position.
- h) The load on the deluge valve shall not exceed the limits mentioned in Table 7.
- j) Indicators shall be provided to show the open and closed positions.
- k) Facility shall be provided to prime the space above the deluge valve seat with water.
- m) It must be ensured that there is no possibility of water leaking back into the instrument air supply in the event of diaphragm failure.
- n) A suitable, durable, robust and clearly visible instruction plate shall be permanently secured to each assembly and shall detail clearly and concisely the following procedures:
 - 1) Start up (or operation),
 - 2) Test,
 - 3) Shut down, or
 - 4) Drain.

9.9.5 Deluge valve shall not be subject to a working pressure of more than 12 bar.

Table 7 Maximum Allowable Flow Through Deluge Valves

[Clauses 8.2.6, 8.6.5.2, 8.7.5.2 and 9.9.4 (h)]

SI No.	Deluge Valve Size mm	Maximum Flow lpm
(1)	(2)	(3)
i)	50	900
ii)	80	1 850
iii)	100	4 000
iv)	150	11 500
v)	200	19 000

9.10 Drainage Provisions (Protection Areas)

Adequate provisions shall be made to promptly and effectively dispose of all liquids from the fire area during operation of all systems in the fire area. Such provision shall be adequate for,

- a) water discharged from fixed fire protection systems at maximum flow conditions;
- b) water likely to be discharged by hose streams;
- c) surface water; and
- d) cooling water normally discharged to the systems.

9.10.1 There are four methods generally adopted for disposal and/or containment that is, grading, dyking, trenching, underground or enclosed drain systems.

The method used in drainage shall be governed by,

- a) the extent of the hazard;
- b) clear space available; and
- c) the protection required.

Where the hazard is low, the clear space is adequate and degree of protection required is not great, grading is acceptable. Where these conditions are not present, consideration shall be given to dykes, trenches or underground or enclosed drains. Where grading is employed, a slope of not less than 1 percent shall be necessary. Concrete surfacing is mostly desirable, however, other hard surfacing are acceptable.

Where dyking is employed, the drainage arrangements thereof shall conform to *Indian Petroleum Rules* in all respects. Where trenching, underground or enclosed drains are employed necessary approval of the Authority may be taken.

9.11 Alarms and Alarm Devices

Each deluge valve set shall be provided with a water motor alarm suitable for spray service located as close as possible to the deluge valve. Electrically operated alarm shall also be accepted. Alarm gong shall go into operation within a maximum of 90 s of opening of deluge valve. Water motor alarm gong shall comply with various provisions of IS 15105.

Each water motor/electric alarm gong shall be prominently marked with the number of the installation to indicate the building/area protected by the deluge valve. The water motor shall be installed with its gong on the outside of an exterior wall and with its centre line not higher than 6 m above the point of connection to the deluge valve. A strainer, readily accessible for cleaning, shall be fitted between the motor nozzle and the deluge valve connection. The water outlet shall be positioned so that any flow of water can be seen.

The pipework to the water motor alarm gong shall be galvanized, medium grade steel complying with IS 1239 (Parts 1 and 2). The equivalent length of pipe

between the deluge valve and the water motor shall be not more than 20 m assuming an equivalent length of 3 m for each change of direction. The nominal size shall be not less than,

- a) 15 mm for equivalent lengths less than or equal to 6 m; and
- b) 20 mm for equivalent lengths greater than 6 m.

Any device to reduce the frequency of false or intermittent alarms fitted to the spray installation shall be suitable for spray system service.

9.12 Pressure Gauges

9.12.1 General and Specification

Pressure gauges fitted in the installations shall comply with relevant Indian Standards.

The scale subdivision shall not exceed:

- a) 0.2 bar for a maximum scale value upto and including 10 bar.
- b) 0.5 bar for a maximum scale value of more than 10 bar, up to and including 16 bar.

The maximum scale value shall be twice the maximum pressure.

9.12.2 Application of Pressure Gauges

- a) *Deluge valves* — A pressure gauge shall be fitted at each of the following points:
 - 1) Main control valve,
 - 2) Immediately downstream of the deluge valve (designated the 'C' gauge), and
 - 3) Immediately upstream of the main control stop valve (designated the 'B' gauge).
- b) *Water supply connections* — Each pump supply shall be fitted with a damped pressure gauge on the supply pipe immediately downstream of the outlet check valve and upstream of any outlet stop valve.
- c) *Removal* — Means shall be provided to enable each pressure gauge to be removed readily without interruption of the water or air supply to the installation.

9.13 Pressure Regulating Valves (PRVs)

Pressure regulating valves shall be used to restrict unwarranted pressure in the installation and piping, particularly in high rise installations. In any case, PRVs shall be provided where the system pressure is in excess of 12 bar. Pressure gauges shall be provided on the inlet and outlet sides of each PRV. A relief valve shall be provided of size not less than 15 mm on the discharge side of the PRVs so as to relieve excess pressure. Means shall be provided downstream of all PRVs for flow tests at spray system demand.

9.14 Strainers

Main pipe line strainers shall be provided for spray systems utilizing nozzles and projectors with waterways less than 10 mm and for any system where the water is likely to contain obstructive material. Main pipeline strainers shall be so installed as to be easily accessible for flushing and cleaning.

Individual or integral strainers shall be provided at each nozzle/projector where waterways smaller than 5 mm are used. Strainers shall be capable of removing from the water all solids of sufficient size to prevent the spray nozzles from clogging (normally 3 mm perforations are suitable). Strainers shall be normally located just upstream of the system deluge valve and shall be downstream thereof, if any. Strainers shall be capable of allowing continued operation, without seriously increasing the head loss, for a period estimated to be ample considering the type of protection provided, the condition of the water, and other local circumstances.

In some cases, a bypass may be warranted to facilitate periodic cleaning of the strainer at intervals based on water quality and strainer obstruction experience.

9.15 Detection System

Detection systems are designed to detect one or more of three characteristics of a fire that is, smoke, heat and radiation. No one type of detector is most suitable for all applications and final choice will depend on individual circumstances.

In any automatic fire detection system, a detector has to discriminate between a fire and the normal environmental conditions. The overall objective of the system is intended not only to enable a fire to be detected at an early stage of its occurrence but also to extinguish the fire without extensive property damage.

Water spray systems (manual or automatic) shall be provided with an audible alarm at the protected premises to indicate that the system has been actuated. When a water spray system is in a remote area, a system for monitoring the alarm should be in place. This monitoring should be at an attended location such as a control room.

Systems shall be automatic for all types of application except certain areas where application is localized or where an efficient detection system cannot be provided. Nevertheless, automatic actuation is still considered a preferred approach for remote or unstaffed locations needing fire protection. IS 2189 shall be referred for additional installation requirements for detection systems that are intended to operate water spray systems.

Automatically operated systems can help minimize damage by providing faster operation of the system as

well as provide an alarm for quicker action by facility personnel. Automatic detection can be accomplished by the use of fire and/or gas detection systems installed within the protected area. Fire detection can include all types of electronic or pneumatic systems (discussed in detail in IS 2189), or may use a fixed temperature sprinkler system in accordance with provisions of this standard.

In case of water spray systems, detection systems are required for activating the deluge system for the following applications:

- a) General area protection (indoors);
- b) Horizontal and vertical vessels (outdoors);
- c) Spherical vessels (outdoors);
- d) Transformers (outdoors and indoors);
- e) Spot protection such as oil tanks, turbo-alternator sets, pipe lines, etc (outdoors and indoors);
- f) Cable galleries; and
- g) Conveyors.

For most of the above protections, sprinklers are found in extensive application in view of their suitability.

Sprinklers are not fast enough for certain applications, for example, general areas like, open-sided bottling plants for LPG and the like, open-sided chemical plants handling low flashing solvents, etc, where a quick detection is required to avoid an inferno.

Other types of detectors, such as flame detectors (either infrared or ultra violet types or combination of both), gas detectors, video detectors, etc, are options for much quicker detection and in this regard, provisions in IS 2189 shall be complied with for installation of such detection systems.

The design of detection system by sprinklers varies from application to application in case of water spray systems. Hence all the methods have been separately covered under each section. However, following requirements are common to all types of application and these requirements are listed below:

- 1) Sprinkler piping shall not be less than 25 mm diameter anywhere;
- 2) Total pipeline volume shall not be less than 10 l (0.01 m³);
- 3) Pressure in the detection system shall, in no case, exceed 3.5 bar;
- 4) Detection piping shall slope to drain at least 1 in 250 with drain valves provided at the lowest point; and
- 5) For pneumatic, separate air compressor shall be provided for the detection system. The air compressor shall be installed in the fire pump room. Where it is not possible, the air compressor

room shall be separated from the occupancies adjoining therewith as per 10.3(c).

- 6) Wherever possible, in case of pneumatic systems, standby air compressor may be installed or supplies from process and utility compressors may be connected as an alternate supply to the detection system.
- 7) As far as possible, the detection piping shall be run alongside the underground spray mains but run independently of other pipes, either underground or aboveground. The piping shall be suitably protected against impact damage in the case of the latter.
- 8) Detection piping shall not traverse underneath or through any working/storage blocks or tank farms/ materials stored in open.
- 9) Temperature rating of the detector sprinkler shall be at least 30°C above the highest ambient temperature at the site of installation.
- 10) Detection piping and equipment installed in corrosive areas shall be applied with protective coatings.
- 11) Detection piping and equipment shall be supported independently as far as possible.
- 12) Detection piping/equipment shall be laid away from hot sources, such as heat exchangers, furnaces, ovens, etc in order to avoid possible false alarms.
- 13) Sprinkler heads shall be provided with guards in areas where they are susceptible to mechanical damage and care shall be taken to see that the guards do not interfere with the spray pattern in the vicinity.
- 14) Detection system shall be designed to cause actuation of the deluge valve within 20 s under expected exposure conditions.
- 15) It is recommended to provide baffle plates for detectors where situation warrants.

10 PUMPSETS

10.1 Pumping Capacity Requirement

- a) To determine the actual pumping capacity required for the system, individual demands of various detached buildings/equipment within the complex shall be determined based on the design details given in the previous sections.
- b) The pumping capacity required shall be equivalent to the highest of the demands thus calculated in (a) above.
- c) Suitable pump shall then be selected to match with the duty parameters as shown in Table 8.

10.2 General Requirements

The following requirements are applicable:

- a) Pump sets shall be exclusively used for the spray systems and shall be of an approved type and shall be one of the following types:
 - 1) Electric motor driven centrifugal pumps;
 - 2) Compression ignition engine driven centrifugal pumps; and
 - 3) Vertical turbine submersible pumps.

In all the above cases, pumps shall be automatic in action.

NOTE — Tappings from the hydrant system to feed water spray systems for smaller installations may be permitted by the Authority. Pump selection and capacity in such cases shall be as per IS 13039.

- b) Pumps shall be direct coupled except in the case of engine driven vertical turbine pumps wherein gear drives shall be used. Belt driven pumps shall be avoided.
- c) Parts of pumps like impeller, shaft sleeve, wearing ring, etc, shall be of non-corrosive metal preferably of brass or bronze.
- d) Where seawater is used or where the quality of the water necessitates the use of special metals and alloys, the use of such metals and alloys shall be insisted upon.
- e) The rating and design of motors and switchgear shall conform to the relevant Indian Standard specifications. The motor shall be of continuous rating type and its rating shall be equivalent to the horse power required to drive the pump at 150 percent of its rated discharge. Pumps shall be chosen with minimum duty parameters as stated in Table 8.
- f) In case of electrically driven pumps, it is required to provide a compression ignition engine driven stationary pump of similar capacity be installed as a standby; and vice versa.

NOTE — Notwithstanding the above, if power to motorized fire pumps is obtained from two sources, one of which is a captive generating plant located in a block either 6 m away from all surrounding building or, where this is not feasible, fire separated from adjoining buildings in a manner indicated in 10.3, more than one pump may be of the electrically driven type.

- g) In case of jockey pumps in such systems to take care of minor leakages, the capacity thereof shall not be less than 3 percent and normally not more than 10 percent of the installed pumping capacity.
- h) Each pump shall be provided with a pressure gauge on delivery side between the pump and non-return valve and a plate giving delivery head, capacity and the number of revolutions per minute.

Table 8 Minimum Duty Parameters for Selecting Pumps

[Clauses 10.1 (c) and 10.2(e)]

Sl No.	Protection Type	Pumping Capacity lpm (m ³ /h)	Delivery Pressure bar
(1)	(2)	(3)	(4)
i)	High velocity	2 850 (171)	7.0/8.8
		4 550 (273)	7.0/8.8
ii)	Medium velocity	2 850 (171)	7.0/8.8
		4 550 (273)	7.0/8.8
		6 750 (410)	7.0/8.8
iii)	Drenchers/curtains	2 850 (171)	7.0
		4 550 (273)	7.0

- j) Each pump shall be provided with independent suction pipe with flooded suction and further provided with sluice or cut off valves. The net positive suction head (NPSH) available at site exceeds the required NPSH by at least 1 m at 110 percent of the duty point as per the manufacturer's curves.
- k) Suction piping shall be laid either horizontal or with a continuous slight rise towards the pump to avoid the possibility of air locks forming in the pipe. No butterfly valves are allowable in suction pipelines.
- m) The diameter of the suction pipe shall be such that the rate of flow of water through it is based upon a rate of flow of 120 m/min (*Max*).

10.3 Pump Room Location

- a) Pumps shall not be installed in the open. The pump room shall be so located as to be both easily accessible and where any falling masonry and the like from other buildings occasioned by fire or other causes, cannot damage the pump room.
- b) Normally, pump rooms shall be located 6 m away from all surrounding buildings and overhead structures.
- c) Where this is not feasible, they may be attached to a building provided a fire wall having a rating of at least 2 h is constructed between the pump room and attached building, the roof of pump room is of RCC construction at least 100 mm thick and access to the pump room is from the outside.
- d) The pump rooms shall normally have brick/concrete walls and non-combustible roof, with adequate lighting, ventilation and drainage arrangements.

- e) The pump room shall be located 30 m clear of the equipment/vessels handling or storing flammable liquids/solvents and/or gases.

10.4 Requirements for Electrical Pumps

- a) The sub-station(s) and/or DG house(s) supplying power to the fire pump(s) shall be of incombustible construction and shall be located at least 6 m away from all surrounding buildings. Where this is not feasible, all door and window openings of the surrounding buildings within 6 m of the sub-station(s) and/or DG house(s) shall be protected by single fire doors and 6 mm thick wired glass in steel framework, respectively. Likewise, roof eaves, if any of the surrounding buildings falling within 6 m of the sub-station(s) and/or DG house(s) shall be cut and wall raised as a parapet. The above provision shall also apply when the substation(s) and/or DG house(s) are within 6 m of each other.
- b) Where the sub-station(s) and/or DG house(s) are attached to buildings, a fire wall(s) having a rating of at least 2 h shall be constructed to segregate the substation(s) and/or DG house(s) from the attached buildings and where the attached building is storeyed, the roof of the sub-station(s) and/or DG houses shall be of RCC construction of at least 100 mm thickness.
- c) Transformer cubicles inside these substations shall be separated from HT/LT cubicles and from each other by blank brick/stone/concrete walls of 355 mm thickness or of RCC of 200 mm with door openings, if any, therein being protected by single fireproof doors with fire rating of at least 2 h. The sub-station(s) and DG houses shall also be separated from each other as above.
- d) Transformers installed outdoors which are supplying power to fire pump(s), shall also be located at least 6 m away from all the surrounding buildings [(including sub-station(s) and/or DG house(s))].
Where this is not feasible, all door and window openings of the surrounding buildings [(including sub-station(s) and/or DG house(s))] within 6 m of the of the transformers shall be protected by single fire doors and 6 mm thick wired glass in steel framework, respectively. Likewise, roof eaves, if any of the surrounding buildings falling within 6 m of the transformers shall be cut and wall raised as a parapet.
- e) Blast walls of bricks/stone/concrete blocks of 355 mm thickness or of RCC of 200 mm thickness shall be constructed between two transformers and these walls shall be extended horizontally by 600 mm beyond the extremities of the transformers and vertically 600 mm above the highest point of the transformers.

NOTE — For high hazard occupancies, substation(s) supplying power to fire pumps shall, in addition to complying with the above provisions, be located 30 m clear of all equipment where flammable fluids having a flash point below 65°C are handled and/or stored.

- f) Overhead feeders to sub-station(s) supplying power to the fire pump(s) are not permitted within a horizontal distance of:
 - 1) 15 m of any process building/plant or tanks containing flammable liquids, or
 - 2) 6 m of any other building or tanks containing non-flammable liquids or of storage in open.
- g) In case the feed to such sub-station(s) is by means of underground cables, the cables shall not pass under any building or permanent structure.
- h) Sufficient spare power shall always be available to drive pumping set(s) at all times throughout the year.
- j) The electric supply to the pumping set(s) shall be entirely independent of all other equipment in the premises that is even when the power throughout the entire premises is switched off, the supply to the pump shall continue to be available uninterrupted. This can be achieved by taking the connection for the pump(s) from the incoming side of the main LT breaker.
- k) However, in cases where two or more transformers and/or sources of supply are connected to a common bus bar or where there is provision of a bus coupler between the bus bar sections, the connection may be taken through the bus bars.
- m) The fire pump circuit shall be protected at the origin by an automatic circuit breaker so set as to permit the motor to be overloaded during an emergency to the maximum limit permissible by the manufacturers. Further, the under voltage release/no volt coil of the circuit breaker shall be removed.
NOTE — Where cable lengths are long enough to warrant back-up protection, Authorities may insist on provision for such a protection.
- n) It is recommended that telltale lamps which could continuously glow when power is available to the fire pump(s) circuit be provided and fixed in a prominent position, both in the substation and in the pump room.
- p) A direct feeder without any tapplings, shall be laid from the substation to the pump house. The feeder shall be laid underground and shall not pass under any building or permanent structure.
- q) Where there is more than one source of power for the operation of pumping set(s) every electrical circuit shall preferably be so designed as to ensure that when necessary the set(s) continue to operate without the manual operation of an emergency switch.

- r) The pumping set(s) shall be securely mounted on a robust bedplate, if of the horizontal type, and shall be free from vibration at all variations of load.
 - s) The rating and design of motors and switchgear shall conform to the relevant Indian Standard specifications. The motor shall be of continuous rating type and its ratings shall be equivalent to the horse power required to drive the pump at 150 percent of its rated discharge.
 - t) The motor shall be of totally enclosed type or drip proof type, the latter having their air inlets and outlets protected with meshed wire panels to exclude rodents, reptiles and insects.
 - u) The motor(s) shall be wound for Class B insulation preferably for Class E and the windings shall be vacuum impregnated with heat and moisture resisting varnish and preferably glass fibre insulated to withstand tropical conditions.
 - w) Motor(s) wound for high tension supplies shall have a suitable fixed warming resistance to maintain the motor windings in a dry condition at all times and particularly under monsoon conditions. The resistance shall be connected to the lighting or other equivalent circuit. Also pump motor and the switchgear inside pump house shall be housed in an enclosure with a degree of protection not less than IP 65.
 - y) Heating apparatus shall also be provided when necessary for medium tension motor where they are located below ground level, in order to maintain the motor windings in a dry condition. Adequate drainage arrangements shall also be provided in the pump house in such cases.
 - z) The incoming cable to the fire pump room shall terminate in an isolating switch fuse unit incorporating the HRC fuses and where necessary provided with a distribution system.
 - aa) The starting switchgear for the fire pumps shall be suitable for direct on line starting but other alternative arrangements are subject to prior approval of the authorities concerned. It shall also incorporate an ammeter with a clear indication of the motor full load current.
- NOTE — Remote controlled starting arrangements are subject to prior approval of the authorities concerned.
- bb) Cables for motors and switchgears shall be armored or enclosed in heavy gauge screwed steel conduit according to conditions.
 - cc) It is recommended that the equipment throughout be painted fire red (shade no. 536 as per IS 5) and suitably marked for identification.
 - dd) Necessary spare parts including a set of fuses (in a glass fronted box) shall be kept in readiness at all times in the pump house.

NOTE — The wiring for the fire pumps in all installations shall be done in accordance with SP 30.

10.5 Compression Ignition Engine Driven Pumps

- a) *Pump room* — The pump room shall be artificially heated, if necessary to maintain the temperature of room above 10°C. Adequate ventilation shall be provided for the air required for aspiration and to limit the temperature rise in the room to 10°C above the ambient temperature when the engine is on full load.
- b) *Engine* — The engine shall be of the compression ignition mechanical direct injection type, capable of being started without the use of wicks, cartridges, heater plugs or ether, at an engine room temperature of 7°C and shall accept full load within 15 s from the receipt of the signal to start:
 - 1) Naturally aspirated, supercharged or turbocharged and either air or water cooled. In case of charged air cooling by means of a belt driven fan or of a belt driven auxiliary water pump there shall be multiple belts such that should half the belts break, the remaining belts would be capable of driving the fan or pump.
 - 2) Capable of operating continuously on full load at the site elevation for a period of 6 h.
 - 3) Provided with an adjustable governor to control the engine speed within 10 percent of its rated speed under any conditions of load up to the full load rating. The governor shall be set to maintain the rated pump speed at maximum pump load.
 - 4) Provided with an in-built tachometer to indicate the rpm of the engine.
 - 5) Provided with a time totalizer (hour counter).
 - 6) Any manual device fitted to the engine which could prevent the engine starting shall return automatically to the normal position.
- c) Engines, after correction for altitude and ambient temperature shall have bare engine horsepower rating equivalent to the higher of the following two values:
 - 1) 20 percent in excess of the maximum brake horsepower required to drive the pump at its duty point; or
 - 2) Brake horsepower required to drive the pump at 150 percent of its rated discharge.
- d) The coupling between the engine and the pump shall allow each unit to be removed without disturbing the other.
- e) *Cooling System* — The following systems are acceptable:
 - 1) Cooling by water from the discharge of fire pump (taken off prior to the pump discharge valve) direct into the engine cylinder jackets

via pressure reducing device to limit the applied pressure to a safe value as specified by the engine manufacturer. The outlet connection from this system shall terminate at least 150 mm above the engine water outlet pipe and be directed into an open tundish so that the discharge water is visible.

- 2) A heat exchanger, the raw water being supplied from the fire pump discharge (taken off prior to the pump discharge valve) via pressure reducing device, if necessary, to limit the applied pressure to a safe value as specified by the engine manufacturer. The raw water outlet connection shall be so designed that the discharged water can be readily observed. The water in the closed circuits shall not be less than that recommended by the engine manufacturer. If the auxiliary pump is belt driven there shall be multiple belts so that should half the belts break, the remaining belts shall be capable of driving the pump.
 - 3) A frame or engine mounted air cooled radiator with a multiple belts driven fan from the engine. When half the belts are broken the remaining belts shall be capable of driving the fan. The water in the closed circuit shall be circulated by means of the auxiliary pump driven by the engine and the capacity of the closed circuit shall be not less than that recommended by the engine manufacturer.
 - 4) Direct air cooling of the engine by means of multiple belts driven fan. When half the belts are broken the remaining belts shall be capable of driving the fan.
- NOTE — In case of systems described above, a failure actuated audio-visual alarm shall be incorporated.
- f) *Air filtration* — The air intake shall be fitted with the filter of adequate size to prevent foreign matter entering the engine.
 - g) *Exhaust system* — The exhaust shall be fitted with a suitable silencer and the total back pressure shall not exceed the engine maker's recommendation. When the exhaust system rises above the engine, means shall be provided to prevent any condensate flowing into the engine.
 - h) *Engine shutdown mechanism* — This shall be manually operated and return automatically to the starting position after use.
 - j) *Fuel system*

- 1) *Fuel* — The engine fuel oil shall be of quality and grade specified by engine makers. There shall be kept on hand at all times sufficient fuel to run the engine on full load for 3 h, in addition to that in the fuel tank.
- 2) *Fuel tank* — The fuel tank shall be of welded steel construction relevant to Indian or

International Standard for mild steel drums. The tank shall be mounted above the engine fuel pump; to provide gravity feed unless otherwise recommended by the manufacturers. The tank shall be fitted with an indicator showing the level of fuel in the tank. The capacity of the tank shall be sufficient to allow the engine to run on full load for:

- i) Light hazard : 1 h
- ii) Ordinary hazard : 2 h
- iii) High hazard : 3 h

NOTE — Where there is more than one compression ignition engine driven pump set, there shall be separate fuel tank and fuel feed pipe for each engine.

- 3) *Fuel feed pipes* — Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position. Pipe joints shall not be soldered and plastic tubing shall not be used.
 - k) *Auxiliary Equipment* — The following shall be provided:
 - 1) Sludge and sediment trap,
 - 2) A fuel level gauge,
 - 3) An inspection and cleaning hole,
 - 4) A filter between the fuel tank and fuel pump mounted in an accessible position for cleaning, and
 - 5) Means to enable the entire fuel system to be bled of air. Air relief cocks are not allowed; screwed plugs are permitted.
 - m) *Starting Mechanism* — Provision shall be made for two separate methods of engine starting, namely:
 - 1) Automatic starting by means of a battery powered electric starter motor incorporating the axial displacement type of pinion, having automatic repeat start facilities initiated by a fall in pressure in the water supply pipe to the spray installation. The battery capacity shall be adequate for ten consecutive starts without recharging with a cold engine under full compression.
 - 2) Manual starting by crank handle, if engine size permits or electric starter motor.
- NOTE — The starter motor used for automatic starting may also be used for manual starting provided there are separate batteries for manual starting.
- n) *Battery charging* — The means of charging batteries shall be by a 2-rate trickle charger with manual selection of boost charge and the batteries shall be charged in position. Where separate batteries are provided for automatic and manual starting the charging equipment shall be capable of

- trickle charging both the batteries simultaneously. Equipment shall be provided to determine the state of charge of the batteries.
- p) *Tools* — A standard kit of tools shall be provided with the engine and kept on hand at all times.
- q) *Spare parts* — The following spare parts shall be supplied with the engine and kept ready:
- 1) Two sets of fuel filters, elements and seals;
 - 2) Two sets of lubricating oil filters, elements and seals;
 - 3) Two sets of belts (wherever used);
 - 4) One complete set of engine joints, gaskets and hoses;
 - 5) Two injector nozzles;
 - 6) One complete set of piston rings for each cylinder; and
 - 7) One inlet valve and one exhaust valve.
- r) *Engine exercising* — The test shall be for a period of at least 5 min each day. Where closed circuits cooling systems are used, the water level in the primary system shall be checked at the time of carrying out each test and, if necessary, water shall be added during the course of test procedure.
- s) A written declaration shall be given that the following conditions will be strictly complied with to:
- 1) Test the engine at least once a week;
 - 2) Maintain the temperature of the engine room at not less than 4.5°C at all times;
 - 3) Maintain the minimum quantity of fuel oil required as desired in these clauses;
 - 4) Use a good grade of fuel oil equivalent in quality to that specified by the engine maker; and
 - 5) Keep on hand the spare parts required as specified in 10.5 (q).
- 10.6 Other Requirements for Pumps**
- a) Where there is more than one pump set installed, the suction pipes shall be interconnected through a common header.
- b) Where a redundant system is required, the full flow demand of the system shall be met by a main pump set and a reserve pump set having the same capacity.
- c) Two pressure sensing devices shall be provided to start each pump set. They shall be connected in series such that opening the contacts of either switch will start the pump set with normally closed contacts.
- d) Means shall be provided for testing pump set starting with each pressure sensing device.
- e) If any isolating valve is installed on the connection between trunk main and any pump set starting pressure sensing device, a non-return valve shall be installed in parallel with the isolating valve so that a fall in pressure on the trunk main will be transmitted to the pressure switch even when the isolating valve is closed.
- f) The first pump set shall start automatically when the pressure in the system falls to a value that shall be indicated in the manufacturer design and installation manual.
- g) Where two pump sets are installed, the second ones shall also start automatically at the same pressure as the first one and a delay shall be provided to avoid simultaneous starting of both units.
- h) Once the pump set has started, it shall continue to run until stopped manually.
- j) The following conditions shall be monitored (electric pump):
- 1) power available to the motor and, where a.c. on all three phases;
 - 2) pump on demand;
 - 3) pump running; and
 - 4) start failure.
- k) All monitored conditions shall be visually indicated individually in the pump room. They shall also be visually indicated at a location permanently attended by responsible personnel. Pump running and fault alarms shall also be audibly indicated at the same place.
- m) Starter alarm indication (engine driven pump set). The following conditions shall each be indicated both locally and at a responsibly manned location:
- 1) Use of any switch which prevents the engine starting automatically;
 - 2) Failure of the engine to start after the six attempts;
 - 3) Pump running; and
 - 4) Diesel controller
- n) When commissioning an installation the automatic starting system of the diesel engine shall be activated with the fuel supply isolated for the six cycles each of no less than 15 s cranking and no more than 15 s or less than 10 s rest. After completion of the six starting cycles the fail to start alarm shall operate. The fuel supply shall then be restored and the engine shall start when the manual start test button is turned on.

11 WATER SUPPLY ARRANGEMENTS FOR SPRAY SYSTEM

11.1 Water Supply

- a) When more than one water based fire protection system complying with respective Indian Standards exist for one complex, water capacity shall be provided, considering the aggregate requirements for all such systems.
- b) Water for the spray system shall be stored in any easily accessible surface or underground reservoir or above ground tanks of steel, concrete or masonry. The effective capacity of the reservoir (above the level of suction puddle flange or the level of top of the pump casing whichever is higher by a height equivalent to three times the diameter of the suction pipe in case of positive suction) for various classes of occupancies of sprinkler installations shall be as indicated in Table 9.
- c) If spray system protection is also backed up by an independent up-to-date hydrant system as per IS 13039, water requirement for spray system shall comply with Table 9.
- d) If spray system protection is not backed up by an up-to-date hydrant system, water requirement for spray system shall need to be loaded for supplementing the protection with hose streams as detailed below:
 - 1) High velocity system : 20 m³
 - 2) Medium velocity system : 50 m³
 - 3) Drencher/curtain system : 50 m³

11.2 Multiple Installations

For designing systems for multiple classifications, that is, mix of high velocity and medium velocity water spray systems, water supply requirements and duration of water supply shall comply with following:

- a) Water supply shall be worked out for each system and highest requirement shall be determined.
- b) Water supply shall be adequate to cater to the highest requirement within the system.

11.3 Water requirements for drencher/curtain system shall be independent and water requirements shall be in addition to what is calculated in **11.2**.

11.4 Other Requirements

A higher capacity of reservoir that required as per Table 9 may be stipulated by the Authorities where considered necessary. Water supplies for the spray installations shall be free from suspended, fibrous or other matters, which may accumulate in the system pipe work, and it is recommended to use filtered water for the system.

The use of salt or brackish water is not normally allowed. In special circumstances where there is no suitable fresh water source available, consideration may be given for the use of salt or brackish water provided the installation is normally charged with fresh water.

Combined reservoirs for other fire fighting systems such as, hydrant system, sprinkler systems, etc, along with water spray system are permissible provided:

- a) All the suction inlets or foot valves are at same level, and

Table 9 Water Storage Requirement for Various Types of Protection

[Clauses 8.2.11, 8.5.5, and 11.1(b), (c) and 11.4]

Sl No.	Protection Type	Exclusive Water Storage
(1)	(2)	(3)
i)	High velocity Spray	a) <i>Transformer protection</i> — Shall not be less than 40 min run for the aggregate pumping capacity for the spray system for control mode (see 7.2.4.5). For suppression mode, 20 min run for the aggregate pumping capacity is acceptable. b) <i>Other local applications</i> — Shall not be less than 10 min run of the aggregate pumping capacity.
ii)	Medium velocity Spray	a) <i>For tankage and spheres:</i> 1) 90 min of the installed pumping capacity if the aggregate hold-up of flammable fluid/solvent in vessels/tanks at one location is less than 200 MT. 2) 150 min of the installed pumping capacity if the aggregate hold-up of flammable fluid/solvent in the vessels/tanks at one location is more than 200 MT. NOTE — For the purpose of the both the above, all storage vessels within 50 m of each other shall be considered as one location. b) <i>Cable galleries</i> — 40 min run of the installed aggregate pumping capacity. c) <i>Conveyors</i> — 60 min run of the installed aggregate pumping capacity.
iii)	Exposure protection	a) <i>Drencher/curtain spray</i> — Not less than 1 h run for the aggregate pumping capacity

- b) Aggregate capacity of the reservoir is equal to the total requirement of all the systems put together.

Reservoirs of and over 225 m³ capacities shall be in two independent but interconnected compartments with a common sump to facilitate cleaning and repairs. The construction and arrangement of the reservoir and the common sump shall be in accordance with the provisions in IS 13039.

Level indicator shall be provided for measuring the quantity of water stored at any time. The indicator shall preferably be graduated to read directly in m³ of water. Water reservoir shall be cleaned at least once in two years or more frequently if necessary to prevent contamination and sedimentation. It is advisable to provide adequate inflow into the reservoir so that the protection can be re-established within a short period.

12 PRE-COMMISSIONING AND MAINTENANCE REQUIREMENTS

12.1 Pre-Commissioning and Acceptance Tests

All new system piping up to the deluge valve shall be hydrostatically tested to a pressure equivalent to 150 percent of the designed head of the fire pump and the system shall be capable of withstanding that pressure for at least 2 h. The coating and wrapping of the underground wrought or mild steel pipes shall be carried out and also subjected to 'Holiday test' as per IS 10221. The entire system piping shall be flushed thoroughly before commissioning in order to remove foreign materials which might have entered/be present in the system piping during the course of installation or which may have been present in existing piping at maximum flow rate available to the system under fire condition. When planning the flushing operations, consideration shall be given to disposal of the water discharged during flushing.

Full discharge test with water shall be made as a means of checking the nozzle layout, discharge pattern, spray coverage and obstructions and determination of relation between design criteria and actual performance and to ensure against clogging of the smaller piping and discharge devices by foreign materials.

The maximum number of systems (deluge valves) that may be expected to operate in case of fire shall be in full operation simultaneously in order to check the adequacy and condition of water supply. The detection system shall be designed to cause actuation of special water control valve within 20 s under expected exposure conditions. Under test conditions the heat detector systems, when exposed to a standard heat source, shall operate within 40 s. Under test conditions the flammable gas detector system, when exposed to a standard test gas concentration, shall operate within 20 s.

NOTE — One method of testing heat detectors is to use a radiant heat surface at a temperature of 150°C and a capacity of 350 W held at a distance of 25 to 30 mm from the nearest part of the detector. This method of testing with electric test set should not be used in hazardous locations. Other test methods may be employed but results shall be related to those obtained under these conditions.

All operating parts of the system including manual override like emergency pull switch of the deluge valve shall be fully tested to ensure that they are in operating condition. The discharge pressure at the highest, most remote nozzle and the lowest nozzle close to the deluge valve shall be measured which should be within the designed limits of the system. For this purpose provisions shall be made for test gauges at appropriate places.

The proper functions of the alarm gong associated with the deluge valve and its level of audibility shall be checked. An audibility level of 85 dB above the background noise level is recommended.

12.2 Periodical Testing and Maintenance

12.2.1 General

Water spray systems require competent and effective care and maintenance to assure that they will perform their purpose effectively at the time of fire. Systems shall be serviced and tested periodically by personnel trained in this work. An inspection contract with a qualified agency for service, test and operation at regular intervals is recommended. Operating and maintenance instruction and layouts shall be available or can be posted at control equipment and at the fire station of the plant. Selected plant personnel shall be trained and assigned the task of operating and maintaining the equipment.

At weekly, or other frequent, regular scheduled plant inspection, equipment shall be checked visually for obvious defects, such as broken or missing parts, external loading or other evidence of impaired protection. At least once a week the system shall be visually checked and the reading of various pressure gauges of each deluge valve installations shall be recorded. A trained pump man shall be available on all shifts and at all hours to operate the pump or whenever required.

12.2.2 Fire Water Reservoirs/Tank

It shall be ensured that fire water tank reservoirs are always full and free from any foreign materials. The water level shall be recorded weekly. Depending upon quality of water, reservoirs shall be cleaned once in a year or two years and sludge formation shall be prevented.

12.2.3 Fire Pumps

All the fire pumps shall be run at least 5 min every day. During testing water level of priming tank, delivery

pressures of pumps, speed, and also other parameters are to be checked and recorded. All pump glands shall be maintained in good working conditions and checked weekly. The bearing grease caps shall be checked once every week and refilled with fresh grease, if necessary. Starter contacts shall be cleaned every week.

Insulation resistance of pump motors shall be examined once in every six months and record shall be maintained. Starting mechanism of diesel engine must be checked, the battery charger and also the batteries must be maintained in effective conditions and the engine shall be run at least for 5 min every day.

12.2.4 Spray System Installations

All piping shall be examined at intervals to determine its conditions. Frequency of inspections will be dependent upon local conditions and shall be at intervals of not more than one year. All the deluge valve installations and automatic detection equipment shall be serviced and tested annually by qualified personnel.

Full discharge test of sprayers shall be made at least quarterly. After each operation, projectors/nozzles equipped with individual strainer shall be removed

and cleaned, unless observations under flow conditions indicate this is not necessary. Manual tripping devices shall be operated at least twice annually.

When normally opened valves are closed following the system operation or test, suitable procedures shall be instituted to ensure that they are reopened and that the system is promptly restored to full normal operating condition. All projectors/nozzles shall be inspected for proper positioning or test, external loading, corrosion and cleaned if necessary, based on experience but at least once in three months.

The entire system shall be flushed at least once a year. It is important to ensure that the sprinkler bulbs (detectors) are kept free from paint or dust (otherwise it may not function correctly) and that the bulbs are accessible and clearly identified for maintenance purposes. All the equipment pertaining to the spray system shall be painted at least once in two years. Spares to the extent of at least 10 percent of each type of sprayers/projectors /sprinklers /detectors shall be kept in stock for quick replacement.

12.3 Periodical Testing and Maintenance Chart

<i>Sl No.</i>	<i>Subject</i>	<i>Activities</i>	<i>Duration</i>
i)	Reservoir	Level checking	Weekly
		Clearing	Once in two years
ii)	Pump	Running test	Daily 5 min
		Test flow	Annually
		Lubrication	Quarterly
		GI and packing	Weekly
		Overhaul	Once in two years
iii)	Engine	Running	Once in day (5 min)
		Lubrication	Quarterly
		Battery	Status weekly
		Load test	Annually
		Overhaul	Once in two years
		Fuel tank check	Daily
iv)	Motor	Lubrication	Weekly
		Starter contact checking	Weekly
		Insulation resistance check	Half yearly
v)	Main piping	Flushing	Once in two years
		Gauge pressure	Check daily
vi)	Sluice valves	Operation	Monthly
		Gland packing	Monthly
		Lubrication	Quarterly
vii)	Deluge valves	Operation	Weekly
		Alarm check	Weekly
		Overhaul	Annually
		Cleaning	Quarterly
viii)	Sprayers	Cleaning	Quarterly
		Flow test	Quarterly

<i>Sl No.</i>	<i>Subject</i>	<i>Activities</i>	<i>Duration</i>
ix)	Detectors	Performance	Six monthly
x)	Spray installation	Performance Physical checkup of piping for seeing dislocation of support, wrong orientation, over-loading, etc.	Quarterly Monthly
xi)	Pressure gauges	Calibration	Annually
xii)	Painting	Painting of entire installation	Every two years

12.4 Hydraulic Calculations — General

a) *Summary Sheet*

The summary sheet should contain the following information:

- 1) Date;
- 2) Location;
- 3) Name of owner and occupant;
- 4) Building or plant unit number;
- 5) Description of hazard;
- 6) Name and address of contractor;
- 7) Design purpose (type of system);
- 8) Minimum rate of water application;
- 9) Total water requirement as calculated including allowance on the hydrant system, where applicable;
- 10) Water supply information in detail; and
- 11) Risk wise details showing the total discharge and pressure at the top of deluge valve.

b) *Detailed Working Sheet*

The detailed working sheet should contain the following information:

- 1) Identification of calculation covered;
- 2) Description and discharge constant (K) for each type of nozzle;

- 3) Hydraulic design reference points;
- 4) Flow, in lpm;
- 5) Pipe size, in mm;
- 6) Pipe lengths, in m, and details of fittings;
- 7) Equivalent pipe lengths for fittings and devices, in m;
- 8) Friction loss, in bar/m;
- 9) Total friction loss between reference points, in bar;
- 10) Elevation head in bar between reference points;
- 11) Required pressure in bar at each reference point;
- 12) Design details of orifice plates;
- 13) Velocity pressure and normal pressure if included in calculations;
- 14) Notes to indicate starting points with reference to other sheets or to clarify data shown;
- 15) Where extending existing system, hydraulic calculations are to be furnished indicating the previous design, flow and pressure at points of connection and adequate additional calculations to indicate the effect on existing system;

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

<i>IS No.</i>	<i>Title</i>
5 : 2007	Colours of ready mixed paints and enamels (<i>sixth revision</i>)
1239	Steel tubes, tubulars and other wrought steel fittings — Specification
(Part 1) : 2004	Steel tubes (<i>sixth revision</i>)
(Part 2) : 2011	Steel pipe fittings (<i>fifth revision</i>)
1536 : 2001	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage — Specification (<i>fourth revision</i>)
1537 : 1976	Specification for vertically cast iron pressure pipes for water, gas and sewage (<i>first revision</i>)
1538 : 1993	Cast iron fittings for pressure pipes for water, gas and sewage — Specification (<i>third revision</i>)
1879 : 2010	Malleable cast iron pipe fittings — Specification (<i>third revision</i>)
2189 : 2008	Selection, installation and maintenance of automatic fire detection and alarm systems — Code of Practice (<i>fourth revision</i>)
3589 : 2001	Steel pipes for water and sewage (168.3 to 2540 mm outside diameter) — Specification (<i>third revision</i>)
7181 : 1986	Specification for horizontally cast iron double flanged pipes for water, gas and sewage (<i>first revision</i>)
8329 : 2000	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage — Specification (<i>third revision</i>)
9523 : 2000	Ductile iron fittings for pressure pipes for water, gas and sewage — Specification (<i>first revision</i>)
10221 : 2008	Coating and wrapping of underground mild steel pipelines — Code of Practice (<i>first revision</i>)
10748 : 2004	Hot rolled steel strip plates for welded tubes and pipe — Specification (<i>second revision</i>)
12392 : 1988	Code of practice for design, manufacture and testing of metallic recuperators
13039 : 2014	External hydrant systems — Provision and maintenance — Code of Practice (<i>first revision</i>)
13095 : 1991	Butterfly valves for general purposes
15105 : 2002	Design and installation of fixed automatic sprinkler fire extinguishing systems — Code of Practice
15301 : 2003	Installation and maintenance of fire fighting pumps — Code of Practice
15908 : 2011	Selection, installation and maintenance of control and indicating equipments for fire detection and alarm system — Code of Practice
SP 30 : 2011	National Electrical Code 2011 (<i>first revision</i>)
SP 46 : 2003	Engineering drawing practice for schools and colleges (<i>first revision</i>)

ANNEX B*(Foreword)***COMMITTEE COMPOSITION**

Fire Fighting Sectional Committee, CED 22

<i>Organization</i>	<i>Representative(s)</i>
Ministry of Home Affairs, New Delhi	SHRI D. K. SHAMI (Chairman)
Agni Controls, Chennai	SHRI D. BALACHANDRAN
Airports Authority of India, New Delhi	SHRI SUBHASH KUMAR SHRI P. K. DESHMUKH (<i>Alternate</i>)
Bhabha Atomic Research Centre, Mumbai	CHIEF FIRE OFFICER
CSIR - Central Building Research Institute, Roorkee	DR R. S. CHIMOTE SHRI SUVIR SINGH (<i>Alternate</i>)
Central Industrial Security Force, New Delhi	SHRI RAJNATH SINGH SHRI N. H. ROUT (<i>Alternate</i>)
Central Public Works Department, New Delhi	SHRI CHAITANYA KUMAR VERMA SHRI D. K. TULANI (<i>Alternate</i>)
Centre for Fire & Explosive Environment Safety (DIFR), New Delhi	SHRI V. K. SHARMA SHRI M. K. JAIN (<i>Alternate</i>)
Chennai Petroleum Corporation Ltd, Chennai	SHRI J. P. K. HEPAT
Chhatariya Rubber & Chemicals Industries, Mumbai	SHRI S. A. HAVELIWALA SHRI H. S. HAVELIWALA (<i>Alternate</i>)
Controllorate of Quality Assurance, Pune	COL V. V. KADAM COL N. K. N. RAO (<i>Alternate</i>)
Delhi Fire Services, New Delhi	DIRECTOR CHIEF FIRE OFFICER (<i>Alternate</i>)
Directorate of Fire and Emergency Services, Goa	SHRI ASHOK MENON SHRI NITIN V. RAIKER (<i>Alternate</i>)
Engineer-in-Chief's Branch, New Delhi	DR SANJAY SHARMA SHRI A. K. DUBEY (<i>Alternate</i>)
Engineers India Ltd, New Delhi	SHRI R. B. BHUTDA SHRI VIPAN GOEL (<i>Alternate</i>)
F. M. Engineering International India Branch, Bengaluru	SHRI SRIKANTH YAJJALA SHRI MANIKANDAN KRISHNAMOORTHY (<i>Alternate</i>)
Fire & Emergency Services, J & K, Srinagar	SHRI V. K. SINGH SHRI BASHIR SHAH (<i>Alternate</i>)
Fire & Security Association of India, Mumbai	REPRESENTATIVE
Fire Protection Association of India, Mumbai	PRESIDENT
GAIL (India) Limited, New Delhi	SHRI S. P. GARG SHRI SANJEEV KUMAR KALKAL (<i>Alternate</i>)
Gunnebo India Pvt Limited, Chennai	SHRI ASHUTOSH SATPUTE SHRI GAJANAN MEDEWAR (<i>Alternate</i>)
H. D. Fire protect Pvt Limited, Thane	SHRI HARISH N. DHARAMSHI SHRI K. T. CHAUDHARI (<i>Alternate</i>)
Indian Oil Corporation Limited, Noida	SHRI AASHISH R. GOKHALE
Institution of Fire Engineers, New Delhi	PRESIDENT GENERAL SECRETARY (<i>Alternate</i>)

<i>Organization</i>	<i>Representative(s)</i>
Johnson Controls India Ltd, Gurugram	SHRI SANTHOSH MUZUMDAR SHRI NITIN RASTOGI (<i>Alternate</i>)
K. V. Fire Chemicals (India) Pvt Ltd, Navi Mumbai	SHRI RAJESH H. SABADRA SHRI UDAY K. SHROFF (<i>Alternate</i>)
Karnataka State Fire and Emergency Services, Bengaluru	SHRI K. U. RAMESH SHRI K. SRINIVASA (<i>Alternate</i>)
Maharashtra Fire Services, Mumbai	DIRECTOR SHRI S. S. WARICK (<i>Alternate</i>)
Mumbai Fire Brigade, Mumbai	SHRI P. S. RAHANGDALE SHRI H. D. PARAB (<i>Alternate</i>)
NBCC (India) Ltd, New Delhi	SHRIMATI SUNITA PURSWANI SHRI R. K. AGARWAL (<i>Alternate</i>)
Oil Industry Safety Directorate, New Delhi	SHRI S. K. NANDY
Reliance Industries Limited, Mumbai	SHRI VARADENDRA KOTI SHRI UMESH KHANDALKAR (<i>Alternate</i>)
RESQ Technologies, Ahmedabad	SHRI ROHIT V. SHAH
Safex Fire Services Limited, Mumbai	SHRI JITENDRA SHAH SHRI SANDIP SHAH (<i>Alternate</i>)
Shah Bhogilal Jethalal & Bros, Ahmedabad	SHRI MUKESH M. SHAH SHRI ABHAY D. PURANDARE (<i>Alternate</i>)
State Bank of India, Mumbai	SHRI VINAYAK GOKHALE
Surex Production and Sales Private Limited, Kolkata	SHRI DEBASHIS NEOGI
Swastik Synergy Engineering Pvt Ltd, Mumbai	SHRI MUKESH D. SHAH SHRI KUNAL ZATAKIA (<i>Alternate</i>)
Tamil Nadu Fire and Rescue Services Department, Chennai	SHRI S. VIJAYASEKAR SHRIMATI N. PRIYA (<i>Alternate</i>)
UL India Pvt Limited, Bengaluru	SHRI JAGDISH V SHRI S. P. TEJ KUMAR BEHARA (<i>Alternate</i>)
Uttar Pradesh Fire Services, Lucknow	SHRI P. K. RAO SHRI AMAN SHARMA (<i>Alternate</i>)
West Bengal Fire and Emergency Service, Kolkata	SHRI ABHIJIT PANDEY SHRI KAMAL NANDY (<i>Alternate</i>)
In personal capacity (B-152, 1st Floor, East of Kailash, New Delhi)	SHRI HEMANT KUMAR
In personal capacity (K-33-A, Green Park, New Delhi)	SHRI S. K. DHERI
In personal capacity (A-45, Sector-70, Noida)	DR H. S. KAPRWAN
In personal capacity (D-317, 2nd Floor, Nirman Vihar, New Delhi)	SHRI R. C. SHARMA
In personal capacity (27A, Tapovan Senior Citizen Foundation, Karadimadai Road, Coimbatore 641010)	SHRI T. R. A. KRISHNAN
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Member Secretary

SHRI S. ARUN KUMAR
SCIENTIST 'D' (CIVIL ENGINEERING), BIS

Fire Fighting Equipments Including Water Fittings Subcommittee , CED 22:2

<i>Organization</i>	<i>Representative(s)</i>
In Personal Capacity (<i>A-45, Sector 70 Noida 201301</i>)	DR H. S. KAPRWAN (Convener)
ASKA Equipment Ltd, New Delhi	SHRI ASHOK H. GARG SHRI NAVDEEP GARG (<i>Alternate</i>)
Ceasefire Industries Limited, Noida	SHRI AMIT KUMAR BAJPAI
Centre for Fire & Explosive Environment Safety (DIFR), New Delhi	DR K. C. WADHWA SHRI PANKAJ CHAWLA (<i>Alternate</i>)
Chennai Petroleum Corp. Limited, Chennai	SHRI J. P. K. HEPAT
Chhatriya Rubbers Chemicals Industries, Mumbai	SHRI S. A. HAVELIWALA SHRI H. S. HAVELIWALA (<i>Alternate</i>)
Controllerate of Quality Assurance, Pune	COL V. V. KADAM COL N. K. N. RAO (<i>Alternate</i>)
Delhi Fire Services, New Delhi	CHIEF FIRE OFFICER DEPUTY CHIEF FIRE OFFICER (<i>Alternate</i>)
Directorate of Fire & Emergency Services, Goa	SHRI ASHOK MENON SHRI NITIN V. RAIKER (<i>Alternate</i>)
G. K. Engg. Co. Limited, New Delhi	SHRI A. K. DHAWAN
Gunnebo India Pvt Limited, Chennai	SHRI ASHUTOSH SATPUTE SHRI GAJANAN MEDEWAR (<i>Alternate</i>)
H. D. Fire protect Co., Thane	SHRI ANIK N. DHARAMSHI SHRI K. T. CHAUDHARI (<i>Alternate</i>)
Institution of Fire Engineers (India), New Delhi	PRESIDENT GENERAL SECRETARY (<i>Alternate</i>)
K. V. Fire Chemicals (India) Pvt. Ltd, Navi Mumbai	SHRI H. M. SABADRA SHRI RAJESH H. SABADRA (<i>Alternate</i>)
Kochi Refineries Limited, Ernakulam	SHRI A. K. DAS
Ministry of Home Affairs, New Delhi	SHRI D.K. SHAMI
Municipal Corporation of Greater Mumbai, Mumbai	CHIEF FIRE OFFICER DEPUTY CHIEF FIRE OFFICER (<i>Alternate</i>)
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Nitin Fire Protection Industries Limited, Mumbai	SHRI NITIN M. SHAH SHRI KUNAL N. SHAHI (<i>Alternate</i>)
Peter Autokits Pvt Limited, Mumbai	SHRI J. K. SHAH SHRI PARESH JOSHI (<i>Alternate</i>)
S & P Safety Products Pvt Limited, Kolkata	SHRI TUNIR CHAKRABARTI
Safex Fire Services Limited, Mumbai	SHRI JITENDRA SHAH SHRI SANDEEP SHAH (<i>Alternate</i>)
Shah Bhogilal Jethalal & Bros, Ahmedabad	SHRI MUKESH M. SHAH SHRI ABHAY D. PURANDARE (<i>Alternate</i>)
Surex Production and Sales (P) Limited, Kolkata	SHRI TARIT SUR SHRI DEBASHIS NEOGI

<i>Organization</i>	<i>Representative(s)</i>
Topaz Fire Systems Pvt Ltd, Bengaluru	SHRI LIAQUT ALI KHAN
In personal capacity (<i>K-33-A, Green Park, New Delhi</i>)	SHRI S. K. DHERI
In personal capacity (<i>D-317, 2nd Floor, Nirman Vihar, New Delhi</i>)	SHRI R. C. SHARMA
In personal capacity (<i>27A, Tapovan Senior Citizens Foundation, Coimbatore 641 010</i>)	SHRI T. R. A. KRISHNAN

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This Indian Standard has been developed from Doc No.: CED 22 (7960).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi